Honokowai Water Quality Management Plan

June 2016

Prepared for:
NOAA Coral Reef Conservation Program

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Executive Summary

The purpose of this report is to characterize the pollutant loading and restoration potential of the 46.4-acre study area mauka of the Honokowai Beach Park (HBP), which was identified in the Wahikuli-Honokowai Watershed Management Plan (WHWMP) as a location for a stormwater improvement project. As with most large-scale planning efforts, additional site investigations are generally required to fully appreciate the management opportunities that can be feasibly implemented at an individual site. To that end, NOAA CRCP funded this study to evaluate the Honokowai drainage area in order to develop a more detailed water quality improvement plan, focusing on stormwater impacts (i.e., not wastewater, groundwater, etc.). This effort included additional field investigations, site topographic survey, mapping of the drainage network (e.g., catch basins, pipes, manholes), and the identification of numerous structural and non-structural stormwater restoration alternatives on public and private property.

To conduct the study, existing information on topography, streams, stormwater infrastructure, outfall locations, etc. was compiled to develop field maps delineating drainage areas and the larger HBP watershed. A field assessment of the HBP was conducted by Horsley Witten to verify the drainage network (e.g., catch basins, pipes, manholes) and identify structural and non-structural stormwater restoration alternatives on public and private property. Primary conclusions from the field investigation include:

- A large portion of the initially estimated watershed is actually connected to the drainage system discharging into Mahinahina Stream (north of the HBP Watershed).
- Most properties in the HBP watershed have very steep driveways and parking lots with little to no stormwater infrastructure. Thus, unmitigated stormwater runoff flows into the HBP Channel without flood control or water quality treatment.
- Most of the properties have 75% impervious cover (e.g., parking, driveways, rooftops, pools, and tennis courts) or higher.
- Rooftop runoff is not typically collected in cisterns on Maui. Given the acreage of rooftops, this represents a lost opportunity to reduce runoff volume and supplement non-potable water supply via rainwater harvesting.

Chapter 1 provides a baseline characterization of the HBP study area, which was divided into four subwatersheds: the land draining to each of the three main outfalls into the HBP channel and the land draining to the Mahinahina Stream. An overwhelming majority (70%) of land in the study area is residential and/or resort properties built in the 1960s and 1970s, prior to the current understanding of the impacts of stormwater and the implementation of low impact

development concepts. Only one stormwater feature was observed in the study area, at the Breakers, a property built in 2008. One possible explanation why water quality best management practices (BMPs) are not present in the study area is that Maui County DPW did not adopt stormwater rules until 2012, after all of the development in the HBP watershed was constructed.

Location of HBP (shown with a star) and Project Study Area (indicated with yellow shading).

Twelve potential stormwater projects were proposed to retrofit existing impervious cover in the watershed; these are described by category in **Chapter 2**. The stormwater BMPs were sized to provide treatment for the 1-inch rain storm where possible per the Maui County requirements. The projects include LID practices proven to provide high pollutant removal of not only sediment, but also nutrients, hydrocarbons, and bacteria. The proposed stormwater projects are grouped into the following categories: retrofit of existing BMP; impervious cover reduction and disconnection; rain gardens and bioretentions; green streets; and constructed wetlands.

A ranking system was developed to help prioritize the identified stormwater projects so that watershed managers will know where to focus first when funds become available. The following factors were used to rank the projects: amount of treated runoff; relative construction cost; ease of implementation (permitting, ownership issues, maintenance burden); and additional benefits/factors (public education/demonstration and available partners). The ranking results and relative costs of the identified structural stormwater projects are summarized in **Table 1**. **Chapter 3** includes the concept designs (10%-30%) for the three projects that ranked the highest: Lahuiokalani Church Rain Gardens, HBP Parking Lot/Lower Honoapiilani Rd Green Streets, and HBP – Constructed Wetland.

Table 1. Structural Stormwater Retrofit Ranking and Relative Cost

Site ID	Name	Ranking Score	Relative Cost*
R-3	**Lahuiokalani Church Rain Garden**	**74.8**	**L****
R-2	**HBP Lower Honoapiilani Rd Green Streets**	**66.2**	**M****
R-1	**HBP Constructed Wetland**	**61.2**	**H****
R-5	Former Parking Lot - Pavement Removal & Restoration	59.6	L
R-8	Haku Hale Place - Green Streets	58.8	M
R-12	Lower Honoapiilani Rd Green Streets	58.0	H
R-4	Vacant Land - Constructed Wetland	54.2	H
R-10	Hale Royale – Bioretention	53.3	L
R-6	Honokowai East Tennis Courts -Porous Surface	46.1	M
R-9	Leinani Apartments - Bioretention	43.0	M
R-7	The Breakers - retrofit existing detention basin	42.9	M
R-11	Kulakane - Bioretention	42.6	M

* L = Low; M = Medium; and H = High.
** A more detailed cost estimate is included in Chapter 3.

Pollution prevention measures are one of the most proactive and cost-effective ways of improving watershed water quality. **Chapter 4** describes a number of specific pollution prevention recommendations to implement in the study area, grouped into two main categories: (1) Source Control; and (2) Education and Outreach Targets.

Chapter 5 describes the recommended next steps, including implementation of both structural stormwater and non-structural pollution prevention recommendations in the plan. Regardless of which projects are selected, permitting considerations, coordination with project partners, and funding are critical components of implementation.

This study illustrates the complexity of watershed planning along an intensely-developed coastline where: 1) little information is available on existing drainage infrastructure; 2) the landscape is dominated by private properties with significant amounts of unmanaged impervious cover; and 3) demand for publicly-owned recreational open space is high. Equally complex are the interactions between watershed runoff, coastal processes, water quality, and their effects on the nearshore ecosystems. This study demonstrates the level of effort that can be required to fully understand the magnitude of runoff issues and illuminate the challenges of successful watershed restoration.

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Chapter 1

Drainage Area Baseline Characterization and Mapping

Honokowai Beach Park (HBP) is a vibrant, well-used park in the Honokowai area. Residents flock to the park for birthday parties with bounce houses; people stop by to eat on their lunch break; and tourists walk over from the farmer's market to enjoy the beach. The parking lot is usually full throughout the day and even into the evening. The HBP has a bath house with outdoor shower, open play areas for kids, picnic tables, and trees for shade. The park is owned by the County of Maui and managed by Maui County Parks and Recreation, with a small portion maintained by the Department of Public Works (DPW).

1.1 Field Reconnaissance

Perhaps the most challenging, and most important, aspect of this project was to delineate and assess the actual drainage areas in the Honokowai area. The study point for this project is the drainage channel that flows along the south edge of HBP – for purposes of this report, we will refer to the channel as the HBP Channel. Three main stormwater outfalls discharge runoff into the HBP Channel:

1. HBP 1: 7' x 1.5' concrete box culvert from the north (parallel to Lower Honoapiilani Rd)
2. HBP 2: 4' x 2' concrete box culvert from the east (slight diagonal across Lower Honoapiilani Rd)
3. HBP 3: 5' x 2' concrete box culvert from the southeast (perpendicular to Lower Honoapiilani Rd)

HBP 2 and 3 are box culverts under Lower Honoapiilani Rd (left); HBP 1 is a large box culvert under the parking lot, indicated with an arrow (right).

The purpose of the field reconnaissance portion of this project was to identify to the extent possible the drainage areas contributing to each outfall. A field map was created using available GIS data from Maui County and the State of Hawaii. However, stormwater infrastructure data was not available at the time of this study. The initial drainage area estimate based on site topography, general knowledge of the area, and information in the Wahikuli-Honokowai Watershed Management Plan (WHWMP) included all of the land west of Honoapiilani Highway and in between the watersheds contributing to Mahinahina and Honokowai Streams.

Excerpt from the WHWMP showing the Mahinahina and Honokowai Streams.

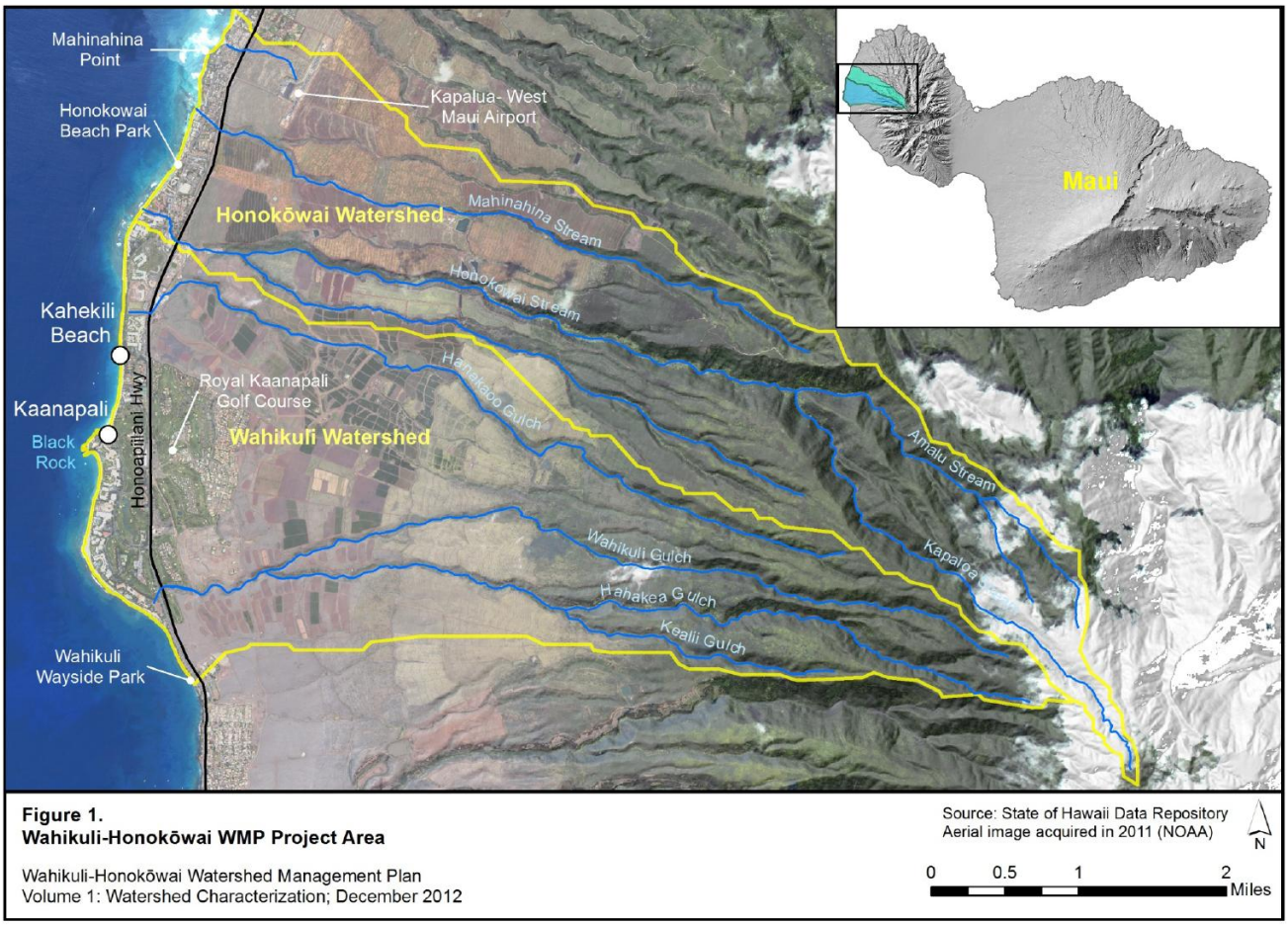

Figure 1.
Wahikuli-Honokōwai WMP Project Area

Wahikuli-Honokōwai Watershed Management Plan
Volume 1: Watershed Characterization; December 2012

Methods

Our general methodology for confirming drainage areas includes the following steps:
Desktop Analysis:

1. Get all available mapping for the area, including topography, streams, stormwater infrastructure (if available), outfall locations, etc.
2. Do a rough delineation of expected drainage area/watershed to a point of interest.
3. Create a field map that at the minimum includes an aerial with identifiable features to provide a frame of reference when performing field investigations.

Field Reconnaissance:

1. Visit the area and follow the topography and identify any visible stormwater infrastructure (e.g., paved flumes, catch basins, drain inlets, manholes, outfalls, open

channels, etc.) and flow paths (e.g., streaking on pavement, eroded gullies, indications of ponded water, etc.). Mark their locations on your field map, connecting the dots where you can (e.g., where you know there is a connecting pipe).

2. If possible, try to look into the catch basins to confirm the pipe sizes and flow direction.
3. Estimate how much of the surrounding land is draining towards the drainage structures to verify and/or correct the initial drainage area delineation.
4. Determine if there are any existing stormwater management practices, and if there are, can they be modified to improve water quality treatment.
5. Identify stormwater retrofit and source control/pollution prevention opportunities to help reduce the amount of pollutants entering the storm drain system.

Field Survey:

1. For structures where you cannot verify flow direction, you may need to go back with survey equipment to open manholes and catch basin covers/grates and measure the invert elevations and pipe diameters. For this study, CDF Engineering was hired to help with determining flow direction and the topographical survey of HBP (See **Appendix A** for Existing Conditions Plan).

CDF Engineering assisted with survey for this project.

For the Honokowai Watershed, this process led to some surprising finds, listed below:

- There is only 1 existing (visible) stormwater management practice in the watershed. In most of the watershed, unmitigated stormwater runoff flows into the HBP Channel without flood control or water quality treatment.
- Many properties in the watershed have very steep driveways and parking lots with little to no stormwater infrastructure – much of the runoff flows directly onto Lower Honoapiilani Rd and into its storm drain network, placing most of the stormwater responsibility and costs onto Maui County DPW.
- There are parallel storm drains along the northern portion of Lower Honoapiilani Rd that direct runoff in different directions; thus, a large portion of the initially estimated watershed is actually connected to the drainage system discharging into Mahinahina Stream (north of the HBP Watershed). However, we still included those areas in this plan. Given the steepness of the driveways in this area, we assumed that some runoff will bypass

the catch basins during heavy rain events, flowing down to Lower Honoapiilani Rd (and into the HBP Watershed) instead of the drainage system to Mahinahina Stream.

- Most of the properties have 75% impervious cover (e.g., parking, driveways, rooftops, pools, and tennis courts) or higher. This amount of hard surfaces not only indicates stormwater quantity and quality issues, but also little open space available for stormwater retrofits. In addition, for many of the sites, the only available open space was located at the top of the drainage area where stormwater cannot be directed for management.
- Most of the properties have a high percentage of rooftops in their drainage areas. This (presumed) cleaner runoff is mostly directed to paved surfaces such as parking areas or roadway. This is a lost opportunity to collect and store rainwater, particularly in this part of Maui where annual rainfall is less than 24 inches a year.

1.2 General Characterization of the Study Area

The Study Area can be divided into four subwatersheds: the land draining to each of the three main outfalls into the HBP channel and the land draining to the Mahinahina Stream (**Table 2**).

Table 2. Summary of Subwatersheds in the Honokowai Study Area

Subwatershed	Acres	% Imp
HBP 1	22.1	67%
HBP 2	10.2	70%
HBP 3	4.6	89%
Subtotal:	**36.9**	**70%**
Mahinahina Stream	9.5	78%
Total:	**46.4**	**72%**

Topography

The topography in the watershed ranges from ~2 feet above sea level at the HBP Channel up to over 60 feet behind the Maui Lani Terraces. Lower Honoapiilani Rd and the immediate area have gentle slopes, while the land between the road and Honoapiilani Highway rises steeply.

Environmental Constraints

A portion of the study area is within the velocity zone (area experiencing high wave action during extreme events) and the 100-year flood zone (floods during the 100-year storm event). Any potential stormwater practices in these areas need to account for extreme events. The entire study area is located within the Special Management Area (SMA), subjecting any project to additional permitting that "provides a means to preserve, protect, and where possible, restore the natural resources of the Coastal Zone of Hawaii by establishing special controls on development within the area along the shoreline" (Maui County website http://www.co.maui.hi.us/index.aspx?NID=1267). See **Figure 1** for the Environmental Constraints Map.

Soils

The soils in our study area include beach sand, Ewa silty clay loam (0-3% slope), Pulehu clay loam (0-3% slope), and Lahaina silty clay (3-7% and 7-15% slope). The sand is good for infiltrating stormwater, but any vegetated stormwater practices in sand will need organic matter added. Loams are good for vegetation, but the fine material (silt and clay) will lower infiltration rates. Silty clay is very tight soil where infiltration is difficult. See **Figure 2** for a map of the soils in the study area.

Land Use and Land Cover

An overwhelming majority of land in the study area is residential and/or resort properties, with mostly vacant transportation land a distant second. The remaining land uses are commercial, roadway, vacant land, historical, and the parking lot at HBP. National-level water quality research has shown trends in pollutant concentrations in stormwater runoff from similar land uses regardless of location. For this project, average stormwater pollutant concentrations by land use (**Table 3**) were used with the Simple Method (Schueler, 1987) to provide planning-level estimates of annual pollutant loads from the study area.

Table 3. Typical Pollutant Concentrations in Stormwater based on Land Use

Land Use	TSS (mg/L)	TP (mg/L)	TN (mg/L)	Bacteria (#Col/ml)
Residential	100	0.3	2.1	7000
Commercial	75	0.2	2.1	4600
Industrial	120	0.25	2.1	2400
Road	150	0.25	2.3	1700
Open Space	51	0.11	1.74	300

Taken from the National Water Quality Database and the Watershed Treatment Model

Table 4 provides the breakdown of land uses and associated pollutant loading. The land cover in the study area is mostly comprised of impervious surfaces. **Table 5** provides a breakdown of the various types of impervious cover and their extent in the watershed. See **Figures 3 and 4** for maps of land use and land cover in the drainage area (DA).

Table 4. Summary of Land Use and Associated Pollutant Loading

Land Use	Acres	% of DA	TSS (lbs/yr)	TP (lbs/yr)	TN (lbs/yr)	Bacteria (Bil Col/yr)
Residential/Resort	32.1	70%	10,938	33	230	3,489
Transportation (State of Hawaii Land)*	6.1	13%	1,060	2	36	28
Commercial	3.4	7%	869	2	24	243
Road	3.3	7%	1,687	3	26	87
Vacant Land*	0.5	1%	87	0	3	2
Historical Church**	0.5	1%	170	1	4	54
Parking Lot (at HBP)***	0.5	1%	256	0	4	13
TOTAL DA:	**46.4**		**15,066**	**41**	**327**	**3,918**

**Assumed pollutant loading values for open space*
***Assumed pollutant loading values for residential*
****Assumed pollutant loading values for roadway*

Table 5. Summary of Land Cover

Land Cover		Acres	% of DA
Impervious Cover	Roadway	3.28	7%
	Driveway	0.82	2%
	Parking Lot	15.5	33.5%
	Rooftop	12.23	26.5%
	Tennis Courts	0.75	2%
	Pool	0.77	2%
	Total Impervious:	**33.3**	**72%**
Pervious Cover	Landscaping	13.1	28%
	TOTAL DA:	**46.4**	

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Legend

- Subwatersheds to HBP Channel
- Subwatershed to Mahinahina Stream

FEMA Flood Zones

- 500-yr Flood Zone
- 100-yr Flood Zone
- Velocity Zone

Storm Drains

- Discharging to HBP-1
- Discharging to HBP-2
- Discharging to HBP-3
- Discharging to Mahinahina Stream
- 5-ft Contours

- Manhole
- Catch Basin
- Curb Inlet
- Outfall

N

0 200

1" = 200 Feet

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Environmental Constraints Honokowai Water Quality Management Plan

Date: 2/12/2016

Figure 1

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Legend

Study Area

Maui Parcels

Soils

- Beach Sand
- Ewa Silty Clay Loam (0-3% Slope) - EaA
- Lahaina Silty Clay (3-7% Slope) - LaB
- Lahaina Silty Clay (7-15% Slope) - LaC
- Pulehu Silt Loam (0-3% Slope) - PpA
- Pulehu Clay Loam (0-3% Slope) - PsA
- Rough Broken and Stony Land - rRS

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0 200

1" = 200 Feet

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Soils
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Figure 2

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Legend

Study Area

Maui Parcels

Land Use

- commercial
- high-density residential
- historical church
- medium-density residential
- parking lot
- roadway
- transportation
- vacant land

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0 200

1" = 200 Feet

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Figure 3

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Legend

- Study Area
- Maui Parcels

Impervious Cover

- Driveway
- Parking Lot
- Pool
- Roadway
- Rooftop
- Tennis Courts

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Figure 4

1.3 Baseline Characterizations of Major Properties in Study Area

The following section describes the major (in terms of size) properties in the study area, starting with the area closest to Mahinahina Stream and working south. **Table 6** provides a summary of all the properties, including when they were built and their addresses for future reference. In general, a majority of the development in this area took place in the 1960s and 1970s, well before the current understanding of the impacts of stormwater and the implementation of low impact development (LID) concepts.

Table 6. Breakdown of Properties in the Honokowai Study Area.

Type	Name	Year Built	Address	Area (acres)	% IC
Condos/Apts	Hale Royale	1980	3788 Lower Honoapiilani Rd	5	75%
	Maui Lani Terraces	1989	3740 Lower Honoapiilani Rd	4	95%
	Leinani Apartments	1970	3750 Lower Honoapiilani Rd	3	72%
	Kulakane	1970	3741 Lower Honoapiilani Rd	0.5	75%
	Nohonani Condos	1974	3723 Lower Honoapiilani Rd	0.3	81%
	Hale Maui Apartment Hotel	1969	3711 Lower Honoapiilani Rd	0.2	62%
	The Pikake	1966	3701 Lower Honoapiilani Rd	0.3	65%
	Hale Kai Condos	1967	3691 Lower Honoapiilani Rd	0.6	90%
	The Breakers	2008	3702 Lower Honoapiilani Rd	3	72%
	West Maui Trades	1978	3676 Lower Honoapiilani Rd	2	84%
	Honokowai East	1973	3660 Lower Honoapiilani Rd	1.5	72%
	Honokowai Palms	1965	3666 Lower Honoapiilani Rd	1	75%
	Sunset Terrace	1987	3626 Lower Honoapiilani Rd	7	85%
	Paki Maui	1975	3615 Lower Honoapiilani Rd	0.3	94%
	Maui Sands	1966	3559 Lower Honoapiilani Rd	0.6	73%
Commercial	Farmer's Market Plaza	1975	3636 Lower Honoapiilani Rd	0.5	88%
	Storage Units/Commercial Area	1987	3600 Lower Honoapiilani Rd	3	93%
Single-family Residential	Haku Hale Place Neighborhood	1997	6-66 Haku Hale Place	3	74%
	Homes just north of Haku Hale	~1953-2006	3726-3732 Lower Honoapiilani Rd	1	80%
	Homes just north of Hale Royale	~1953-1980	3788-3826 Lower Honoapiilani Rd	1	40%
Vacant Land	State of Hawaii Land	NA	Borders Honoapiilani Highway	4	22%
	Former single-family residence	NA	3614 Lower Honoapiilani Rd	0.5	0

Hale Royale

Hale Royale is a large condominium complex (almost 5 acres, over 75% impervious) with extremely steep parking areas that form a ring around the buildings and inner courtyard area. There are tennis courts and a laundry building along the upper, eastern edge of the property (bordering Honoapiilani Highway). There are only a few catch basins for this entire development, all located at the bottom of the slope near Lower Honoapiilani Rd. These catch basins are connected to the storm drain that discharges into the Mahinahina Stream

Watershed; so for small storm events, this development is outside our watershed. However, given the steepness of the parking areas, it is highly likely that at least some of the stormwater from larger storm events bypasses the catch basins and continue to flow down into the street drainage system.

Table 7. Land Cover at Hale Royale

Land Cover	Acres	%
Parking Lot	1.68	35%
Rooftop	1.4	29%
Tennis Courts	0.45	9%
Pool	0.13	3%
Landscaping	1.16	24%
Total	**4.81**	

Looking downhill towards the entrance to Hale Royale (left); looking uphill from the exit (right).

This is the only catch basin to collect the stormwater runoff from the north side of Hale Royale. Sediment streaking on the pavement could indicate that runoff frequently bypasses this catch basin and enters the stormwater drain on Lower Honoapiilani Rd.

Maui Lani Terraces/Leinani Apartments

Maui Lani Terraces is a large (4 acres, 95% impervious) condominium complex built in 1989, while Leinani Apartments, built in 1970, are less than an acre; they are both accessed from the same driveway off Lower Honoapiilani Rd. Runoff from Leinani Apartments and the entrance portion of the driveway flows into catch basins along Lower Honoapiilani Rd. Runoff from Maui Lani Terraces is collected by catch basins and storm drains that carry the stormwater into the Hale Royale drainage system, which discharges into Mahinahina Stream Watershed. Thus, for small storm events, this development is outside our watershed. However, given the steepness of the parking areas, it is highly likely that at least some of the stormwater from larger storm events will bypass the catch basins and continue to flow down into the street drainage system.

Table 8. Land Cover for Maui Lani Terraces and Leinani Apts

Owner	Land Cover	Acres	%
Maui Lani Terraces	Parking Lot	2.45	60%
	Rooftop	1.36	33.5%
	Pool	0.07	2%
	Landscaping	0.19	4.5%
	Total	**4.09**	
Leinani Apartments	Parking Lot	0.18	28%
	Rooftop	0.30	44.5%
	Landscaping	0.18	27.5%
	Total	**0.67**	

The upper parking lot at Maui Lani Terraces showing the extensive pavement and a catch basin at the low point (left); looking uphill from near Leinani Apartments (right).

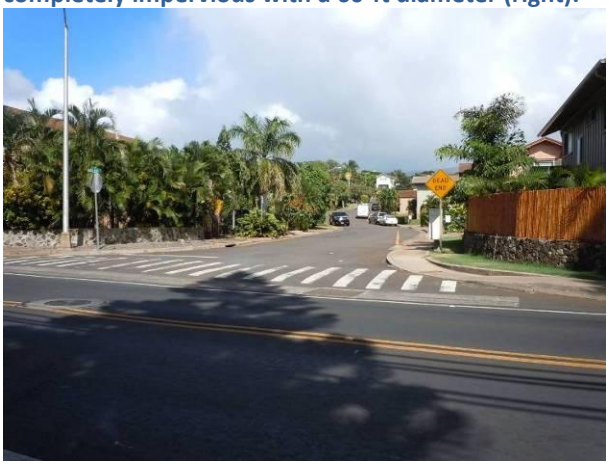
Haku Hale Place - Cul-de-sac

Haku Hale Place is a newer neighborhood than most of the surrounding area (built in 1997). The dead-end road serves 26 houses, with a 60-foot cul-de-sac as a turnaround. The road was designed with two 8-ft wide lanes, and one 8-ft wide on-street parking lane all along the south side. The road is crowned, and stormwater is directed into curb inlets that are connected to the Lower Honoapiilani Rd drainage system, HBP-1.

Table 9. Land Cover at Haku Hale Place

Land Cover	Acres	%
Driveway	0.5	15.6%
Rooftop	1.4	43.8%
Roadway	0.4	12.5%
Landscaping	0.9	28.1%
Total	**3.2**	

This road is wider than typical for a two-lane road because a parking lane was included (left); the cul-de-sac is completely impervious with a 60-ft diameter (right).



Kulakane

Built in 1970, Kulakane is an oceanfront condominium with almost 0.5 acres in the watershed, 68% of which is impervious parking lot. From the field visit, it appears that the rooftop runoff does not discharge onto the parking lot, but is contained in landscaped areas and/or flows toward the ocean. The large parking lot has no stormwater infrastructure; instead, all of the runoff flows toward the low point at the southeastern corner and out onto Lower Honoapiilani Rd.

Table 10. Land Cover at Kulakane

Land Cover	Acres	%
Parking Lot	0.30	68%
Rooftop	0.03	8%
Landscaping	0.1	24%
Total	**0.44**	

The extensive parking lot at Kulakane with no stormwater infrastructure (left); all runoff from the parking area drains to this low point on the property and out into the street (right).

Nohonani Condos and Hale Maui Apartment Hotel

The parking area for the Nohonani Condos and the rooftop from the Hale Maui contribute runoff to the drainage area for HBP-1 without any visible on-site stormwater management. The

Nohonani was built in 1974, while Hale Maui was built in 1969 – both before stormwater treatment standards were in place.

Table 11. Land Cover at Nohonani and Hale Maui

Owner	Land Cover	Acres	%
Nohonani Condos	Parking Lot	0.21	81%
	Landscaping	0.05	19%
	Total	**0.26**	
Hale Maui	Parking Lot	0.03	13%
	Rooftop	0.11	49%
	Landscaping	0.08	38%
	Total	**0.22**	

The Nohonani Condominiums parking lot drains out to Lower Honoapiilani Rd (left); a portion of the roof and parking area of the Hale Maui Apartment Hotel also drains into our study area (right).

The Pikake

The Pikake is a condominium complex constructed in 1966 where the front portion of the property drains toward Lower Honoapiilani Rd while the back portion drains toward the ocean. The portion of the site in our watershed is 0.29 acres that is 65% impervious.

Runoff from the Pikake parking lot flows down to the gutter on Lower Honoapiilani Rd.

Table 12. Land Cover at The Pikake

Land Cover	Acres	%
Parking Lot	0.08	29%
Rooftop	0.11	39%
Landscaping	0.09	32%
Total	**0.29**	

Hale Kai

Hale Kai Condominiums were built in 1967, and the large parking lot and a portion of rooftop drain towards Lower Honoapiilani Rd. No on-site stormwater infrastructure was visible during the field visit.

Table 13. Land Cover at Hale Kai

Land Cover	Acres	%
Parking Lot	0.25	45%
Rooftop	0.25	45%
Landscaping	0.05	10%
Total	**0.55**	

Runoff from the Hale Kai parking lot flows down to the gutter line on Lower Honoapiilani Rd.

The Breakers

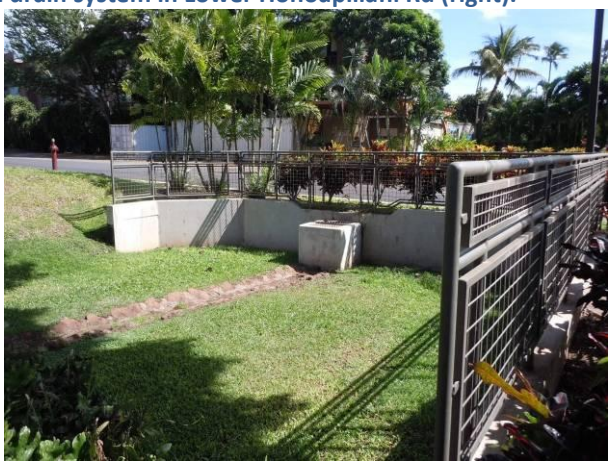
The Breakers is the most recent development in the watershed, built in 2008. Not surprisingly, it is also the only development that has an existing stormwater management practice. The almost 3-acre development is 72% impervious. The rooftops have gutters and downspouts directed to the driveway/parking area. All of the runoff is directed via catch basins/storm drains into an extended dry detention basin located along Lower Honoapiilani Rd. The basin has a hardened (with rocks) low-flow channel that carries runoff from small events directly into the adjacent street storm drain network with no filtering or infiltration; it appears that runoff from larger events will be detained in the basin to some extent, providing some flooding attenuation. The Breakers has a large, grassy open space adjacent to the basin, but existing signage indicated that an additional building would be constructed in this area.

Table 14. Land Cover at The Breakers

Land Cover	Acres	%
Parking Lot	0.94	31.5%
Rooftop	0.94	31.5%
Pool	0.26	9%
Landscaping	0.84	28%
Total	**2.99**	

Downspouts from the roofs direct runoff onto the parking area (left); another building is slated to be constructed on the remaining open space at this site (right).

An extended dry detention basin helps manage runoff from The Breakers (left); a concrete outlet structure controls flow rates out of the basin and into the storm drain system in Lower Honoapiilani Rd (right).



West Maui Trades

West Maui Trades is a 1.8-acre property that was developed in 1978. The site is over 80% impervious with a steep parking area. The rooftop runoff appeared to be directed to the parking area, and no stormwater infrastructure was visible anywhere on site. All runoff appears to enter the Lower Honoapiilani Rd drainage system via curb inlets near the road.

Table 15. Land Cover for West Maui Trades

Land Cover	Acres	%
Parking Lot	1.0	55%
Rooftop	0.5	28.5%
Landscaping	0.3	16.5%
Total	**1.8**	

Runoff from West Maui Trades flows down the steep parking area to curb inlets near the road.

Honokowai Palms and Honokowai East

Honokowai Palms and Honokowai East are two condominium complexes accessed by the same driveway. Both have large expanses of parking and rooftops, as well as outdoor pools. Honokowai East also has a large tennis court, accounting for over 20% of its land area. No stormwater infrastructure was visible for either of these properties, so it is assumed that all runoff flows down the driveway to Lower Honoapiilani Rd.

Table 16. Land Cover for Honokowai Palms and Honokowai

Owner	Land Cover	Acres	%
Honokowai Palms	Parking Lot	0.45	38%
	Rooftop	0.4	32%
	Pool	0.05	5%
	Landscaping	0.3	25%
	Total	**1.2**	
Honokowai East	Parking Lot	0.45	31%
	Rooftop	0.25	16%
	Tennis Courts	0.3	21%
	Pool	0.05	4%
	Landscaping	0.4	28%
	Total	**1.5**	

Driveway entrance to Honokowai Palms and Honokowai East (left); Parking area behind Honokowai East (right).

Farmer's Market Plaza

The Farmer's Market Plaza is one of only two commercial properties in the study area. This area was developed in 1975 and hosts an outdoor market three days a week, as well as an indoor market open all week. There are also a few shops in the front of the building along Lower Honoapiilani Rd. There was no visible stormwater infrastructure, and it appeared that the parking lot and rooftop runoff drains overland into the road and catch basins adjacent to HBP parking lot.

Table 17. Land Cover at the Farmer's Market Plaza

Land Cover	Acres	%
Parking Lot	0.17	35.5%
Rooftop	0.25	52%
Landscaping	0.06	12.5%
Total	**0.48**	

The Farmer's Market Plaza parking lot (left) and building (right).

Sunset Terrace

Sunset Terrace is the largest development in the entire watershed. It was built in 1987 and is comprised of 12 condominium buildings, surrounded by parking areas. There is one pool on the property, as well as landscaping between and behind the buildings. This property has its own drainage network of a series of catch basins and storm drains that discharge into HBP-2, but there are no stormwater practices visible for water quality or flooding control.

Table 18. Land Cover at Sunset Terrace

Land Cover	Acres	%
Parking Lot	3.3	49.8%
Rooftop	2.2	33.2%
Pool	0.2	2.7%
Landscaping	1.0	14.3%
Total	**6.7**	

Driveway entrance to Sunset Terrace (left); catch basin in back parking area (right).

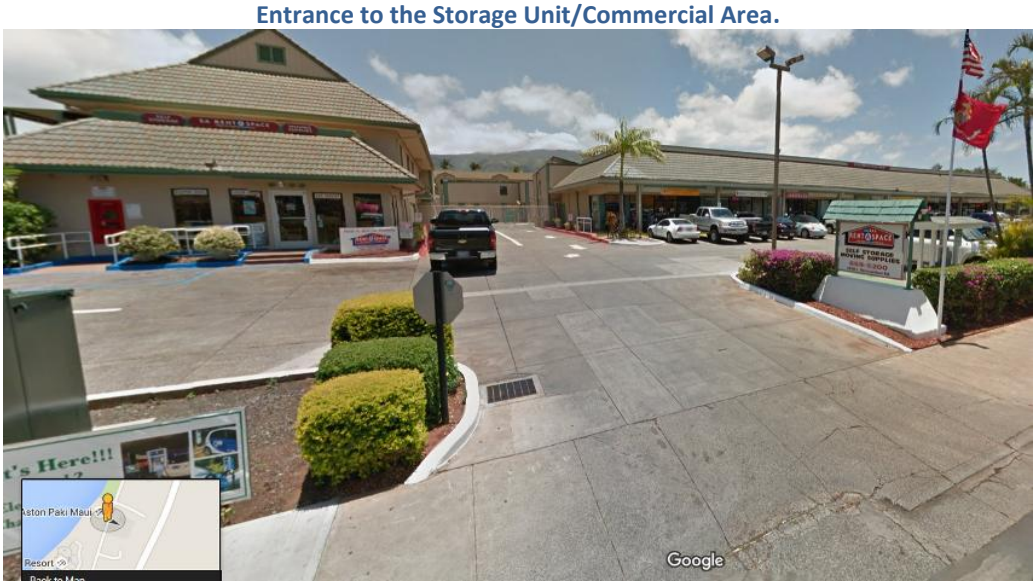
Storage Units/Commercial Property

This commercial property was developed in 1987, and the majority of the property is comprised of storage units and associated parking area. The rest of the property consists of small stores and restaurants and their parking. The entire drainage network at this site was not observed since we did not gain access to the storage unit area, but the catch basin at the entrance was opened, and it was confirmed that this area contributes drainage to HBP-3. This property has the highest impervious cover in the watershed at over 90%, yet there does not appear to be any stormwater management on site.

Table 19. Land Cover at the Storage Units/Commercial Property

Land Cover	Acres	%
Parking Lot	1.2	41.4%
Rooftop	1.5	51.7%
Landscaping	0.2	6.9%
Total	**2.9**	

Entrance to the Storage Unit/Commercial Area.



Chapter 2

Structural Stormwater Management

When it rains, trash, sediment, and other pollutants (e.g., oils, brake fluid, fertilizer) that have collected on roads, parking lots, and other impervious surfaces is washed off into the drainage system. Either through a network of storm drains and underground pipes—or by direct discharge—this contaminated runoff finds its way to streams and, eventually, to the ocean. Once vegetation is removed during the development process, exposed soils are subject to erosion, and rainfall is no longer absorbed by trees or allowed to seep into the ground. Over 70% of the HBP watershed is impervious, which generates large volumes of surface runoff that can lead to flooding problems, erosion, water quality issues, and warmer temperatures of the receiving waterbody.

A number of structural post-construction stormwater management techniques can be used to reduce the impacts of urban stormwater. Several decades ago, stormwater management focused mainly on providing flood control and trapping sediment and debris with best management practices (BMPs) such as detention basins. However, research has shown that pollutants such as nutrients, hydrocarbons, and bacteria were not being removed by those BMPs and were impacting our water resources and coral reefs. Low impact design (LID) or "green infrastructure" is a more recent strategy for more effective stormwater management. LID strategies attempt to mimic nature with practices that capture runoff and either reuse it (with rain barrels and cisterns), allow for evapotranspiration by plants and the sun, infiltrate rainwater into the ground to reduce the volume of surface runoff leaving a site, or utilize soil and plants to filter pollutants out of runoff before discharging it.

In 2012, the Maui County DPW adopted *Rules for the Design of Storm Water Treatment Best Management Practices* that require the treatment of the "water quality volume" (runoff from 1-inch rain storm) and implementation of LID techniques for projects with disturbed area greater than 1 acre. Smaller sites need to also provide site-specific BMPs and non-structural practices. These regulations were adopted after all of the development in the HBP watershed was constructed, which may be the reason that no water quality BMPs were observed during the field reconnaissance. However, many of these developments will need to be redeveloped in the near future, and hopefully, that will provide the perfect opportunity for stormwater retrofits to address the lost opportunities of the past.

Given the total number of projects that would need to be implemented to show measurable downstream results, improved stormwater management at a watershed scale can be expensive and challenging. At a minimum, efforts should be made to prevent new and redevelopment from

further contributing to the problem. Likewise, opportunities to improve conditions during maintenance and repair activities should be aggressively seized. Applicants and reviewers should keep retrofitting opportunities in mind as new permit requests for redevelopment or repair are made at individual, private sites.

The proposed stormwater projects described in this chapter retrofit existing impervious cover in the watershed, providing treatment for the 1-inch rain storm where possible per the Maui County requirements. The projects focus only on LID practices that are proven to provide high pollutant removal, specifically focusing on sediment, bacteria, phosphorus, and nitrogen. **Table 20** summarizes the proposed stormwater projects, and **Figure 5** shows the locations of each, as well as the estimated BMP footprint and contributing drainage area (DA).

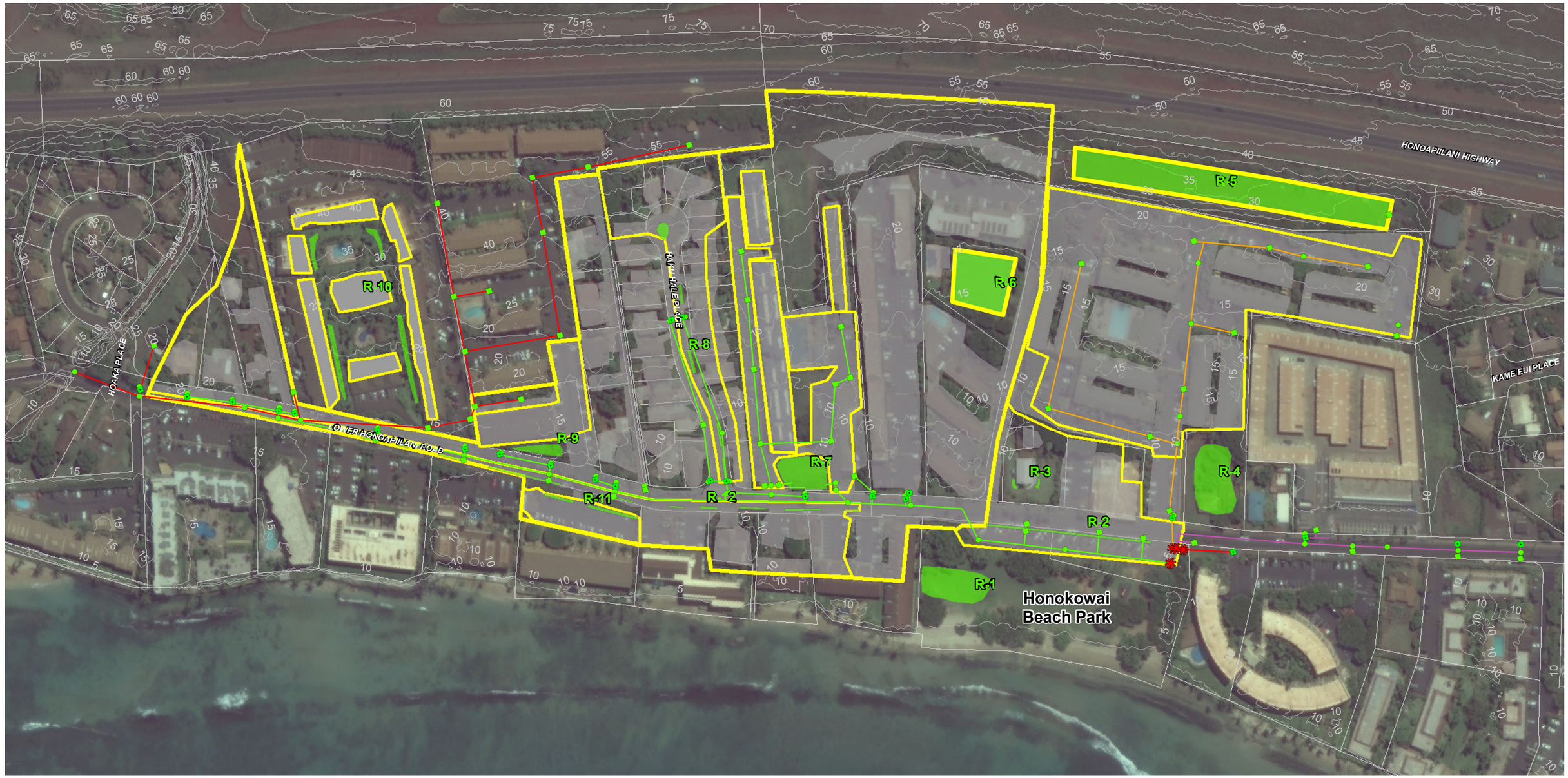
Table 20. Sites for Stormwater Improvement

Type	Site ID	Name	DA (acres)	% Imp
Post-construction Stormwater Retrofits	R-1	HBP Constructed wetland*	20.4	62%
	R-2	HBP/Lower Honoapiilani Rd Green Streets**	1.8	67%
	R-3	Lahuiokalani Church Rain Garden**	0.05	100%
	R-6	Honokowai East Tennis Courts -Porous Surface	0.3	100%
	R-7	The Breakers - retrofit existing detention basin	2	100%
	R-8	Haku Hale Place - Green Streets	1.5	67%
	R-9	Leinani Apartments - Bioretention	0.5	100%
	R-10	Hale Royale – Bioretention**	0.7	100%
	R-11	Kulakane - Bioretention	0.3	100%
	R-12	Lower Honoapiilani Rd Green Streets	0.5	100%
Easements/ land acquisition targets for stormwater	R-4	Vacant Land - Constructed Wetland**	5.5	95%
	R-5	Former Parking Lot - Pavement Removal & Restoration**	0.9	100%
		Total	**27.7**	**70%**

*DA for this site encompasses the DAs for all other sites except where indicated with **.

The projects are described below by category: Retrofit of Existing BMP, Impervious Cover Reduction and Disconnection, Rain Gardens and Bioretentions, Green Streets, and Constructed Wetlands. These projects were chosen for each specific location based on site constraints (e.g., available space, utilities, land use, etc.), assumed groundwater levels, and existing stormwater infrastructure. For more information on these types of designs in the island environment, refer to *Stormwater Management in Pacific and Caribbean Islands: A Practitioner's Guide to Implementing LID* (2013).

Preliminary sizing calculations were completed for each BMP to roughly determine if enough space was available. In general, rain gardens were sized to hold the full 1-inch runoff (not accounting for infiltration). Bioretention areas were sized using an equation that accounts for both surface ponding and filtration through the modified soil; green streets are sized using the bioretention equation. Constructed wetlands are typically sized with a minimum surface area of 1.5% of the entire contributing drainage area (not just the impervious cover). The sizing spreadsheet is included in Appendix B.



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Legend

- Retrofit Drainage Area
- Impervious Cover
- BMP Footprint
- Maui Parcels

Storm Drains

- Discharging to HBP-1
- Discharging to HBP-2
- Discharging to HBP-3
- Discharging to Mahinahina Stream
- 5-ft Contours

- Manhole
- Catch Basin
- Curb Inlet
- Outfall

N

0 200

1" = 200 Feet

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Proposed Stormwater Retrofits Honokowai Water Quality Management Plan

Date: 2/12/2016

Figure 5

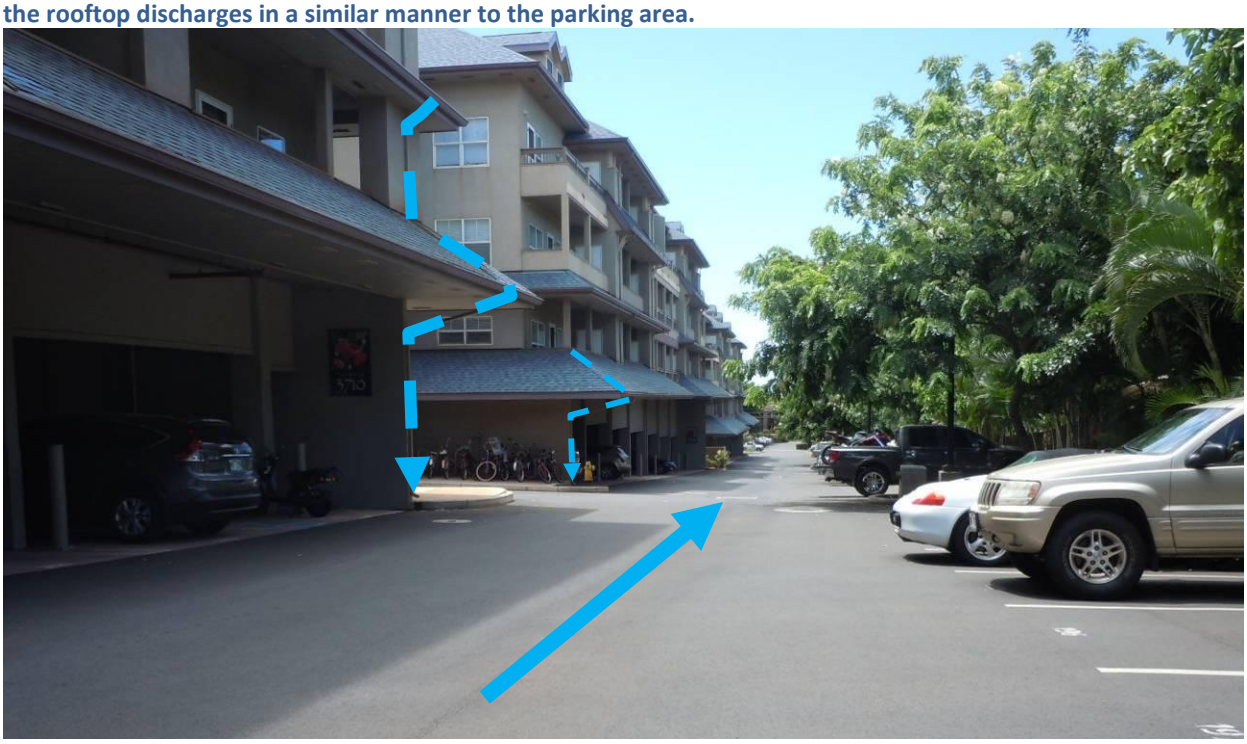
2.1 Retrofit of Existing BMP

R-5: The Breakers – Detention Basin Retrofit and Cisterns

The Breakers is the newest development in the watershed (2008) and has the only observed stormwater BMP – an extended detention basin. There is a total of 2 acres of impervious cover that contributes runoff to the small basin immediately adjacent to Lower Honoapiilani Rd. This includes almost 1 acre of roof top that is directly connected to the parking area via downspouts discharging to the pavement. Runoff is collected by a series of catch basins and directed into the detention basin. Low flows are conveyed with a hardened (appears to be a mortared rock base) low-flow channel with little to no detention before flowing out the orifice in the overflow structure. Runoff from larger storm events will be detained in the basin until the water reaches the top of the overflow structure, where it will flow through the grate and into the storm drain system in the road. The proposed retrofit for this site is to enlarge the existing basin utilizing the open lawn next to the basin (currently slated for future development), providing water quality treatment features such as a sediment forebay for pretreatment, longer flow path for low flows, wetland vegetation to filter and take up nutrients, and greater flood storage for larger events. In addition, the rooftop runoff should be collected in cisterns and reused as much as possible. Allowing the clean roof runoff to flow over a parking lot, picking up all the associated pollutants, is a lost opportunity. This could also provide a good example for other developments in the watershed – almost all buildings have gutters and downspouts for roof runoff, and yet no cisterns or rain barrels were observed. This project does have potential for public education given its location next to the main road, but it is a private development where future buildings are proposed, presenting an implementation challenge.

Looking down the low-flow channel in The Breakers existing detention basin with the proposed basin expansion indicated in green (left); overflow structure for the detention basin showing a low-flow orifice at the same elevation as the channel (right).

Looking down the parking area at The Breakers. A few of the downspouts are shown with blue arrows – all of the rooftop discharges in a similar manner to the parking area.



2.2 Impervious Cover Reduction and Disconnection

R-5: State of Hawaii Property – Former Parking Lot Pavement Removal/Restoration

This 3.8-acre property is located at the top of the watershed next to the Honoapiilani Highway. Much of the site is pervious, except for a 0.9-acre abandoned parking lot. This parking lot is not completely impervious with many cracks where vegetation has started growing. However, we assume that it still creates runoff during larger storm events, adding to downstream flooding and water quality issues. This property presents a great opportunity to revegetate in a highly urbanized, impervious watershed. This area could also be converted into a park with walking paths and picnic tables for the many nearby residents of Sunset Terrace, Honokowai East, West Maui Trades, The Breakers, and more. Pavement removal and revegetation is relatively inexpensive compared to other stormwater retrofit opportunities in the watershed; however, the State ownership of this property could present a challenge if the land is slated for a different purpose. That being said, the State could also be a great partner in this and other projects in the watershed.

Looking down at the abandoned parking lot from the shoulder of Honoapiilani Highway (left); many cracks are visible in the former parking lot with grasses growing up through the pavement (right).


R-6: Honokowai East – Pavement Removal/Permeable Tennis Courts

This condominium complex has tennis courts for its residents to use. The courts are impervious (~12,000 sf) and in need of repair/repaving. The impervious surface could be replaced with a permeable material such as permeable asphalt, porous concrete, or a more flexible permeable surface made of recycled rubber. This type of material could also be used at the other tennis courts in the study area – Hale Royale. While this proposed retrofit would manage runoff from over 20% of the Honokowai East property, it is located on private property and presents little opportunity for public education other than for the condominium residents.

The existing courts at Honokowai East (left); an example of porous asphalt tennis courts (right).


2.3 Rain Gardens and Bioretention Areas

Rain gardens and bioretention areas are very similar BMPs; both use a shallow depression and native plants to treat stormwater runoff. However, they differ in that rain gardens are very simple practices that homeowners and volunteers can design and install, while bioretention

areas are engineered practices that typically have specific filter media, underdrains, overflow structures, etc. Both are recommended in this watershed.

R-3: Lahuiokalani Church Rain Gardens

The Lahuiokalani Church is an historical property owned by the Hawaii Conference of the United Church of Christ. Due to its prominent location along Lower Honoapiilani Rd and large pervious areas, this site is a great location for one or more demonstration rain gardens. The 2,000 sf rooftop has gutters that discharge to the lawn area via downspouts. While this roof is not contributing significant levels of pollutants, if any, to the HBP Channel, it does provide sufficient space and visibility for an effective demonstration project. If educational signage is allowed here, this project could have the potential to reach countless residents and visitors. While the ownership of this property and the historical nature of the site could present challenges to this project, the Hawaii Conference of the United Church of Christ could be a very valuable partner and proponent for this project and others in the watershed.

Sufficient space is available on both sides of the church for rain gardens.

R-9: Leinani Apartments – Bioretention Area

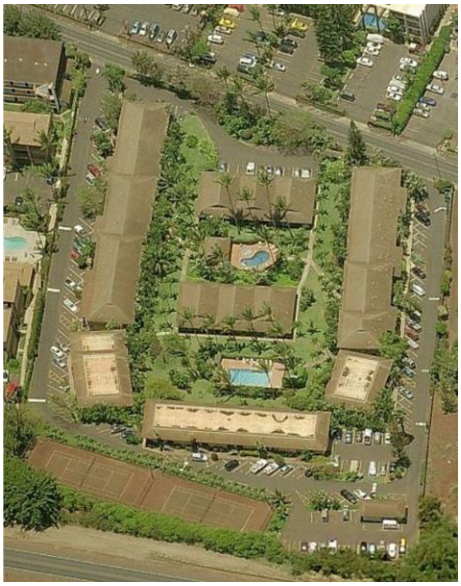
There is a triangular-shaped lawn area in front of Leinani Apartments that could be used to treat stormwater runoff from the rooftop as well as a portion of the parking area/driveway. The proposed retrofit is to construct an 800 sf bioretention area between the apartment building and Lower Honoapiilani Rd to treat runoff from 0.5 acres of roof and parking. This is one of the few properties that has available open space in an area well-positioned to accept stormwater runoff (i.e., downgradient from the contributing drainage area), but it is a private development, which could make implementation challenging and reduces the public education value of this site.

A bioretention area could be constructed at Leinani Apartments as shown below in green.

R-10: Hale Royale – Bioretention Areas

Hale Royale is a rare condominium complex for this watershed – it has landscaped areas incorporated throughout the site, providing many opportunities to integrate stormwater management. Currently, the rooftops discharge to either the steep parking areas toward the outside of the site, or into the grassed courtyard. At a minimum, the courtyard runoff could be directed into bioretention areas that slow, filter, and infiltrate the stormwater. Bioretentions are proposed vs. rain gardens because of the steep grade in the courtyards that will require a stepped system. Depending on how much space the condominium is willing to convert for this purpose, it would also be possible, but much more complicated, to direct some of the parking area runoff into these systems. For simplicity purposes for this study, we have assumed that the bioretention areas will only be sized for the runoff currently flowing into this area (0.7 acres of rooftop). Thus, the bioretentions only need a surface area of 1,100 sf while much more is actually available. This private property may be reluctant to voluntarily take on this project, and the public education potential is mostly limited to the Hale Royale residents. However, this is a site where the bioretention areas could really become integrated in the beautifully landscaped courtyards, providing a great example for other developments in West Maui.

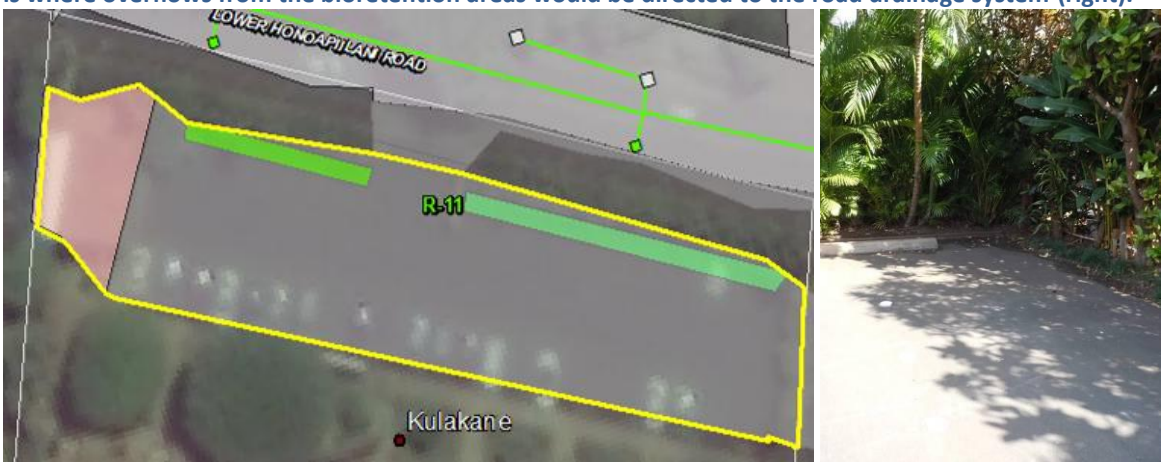
An overview of Hale Royale, showing the parking areas surrounding the buildings, with a courtyard in the middle (left); looking down one of the grassed courtyards (right). Below is a graphic rendering of one of the proposed bioretention areas.



R-11: Kulakane Bioretention

The Kulakane parking lot currently drains toward the mauka edge of the lot, along the curb, and out to Lower Honoapiilani Road along the southeastern corner with no treatment. The proposed retrofit is to utilize the existing flow path by converting the edge of the parking lot into a narrow bioretention swale. This practice would remove 1,000 sf of pavement and treat 0.3 acres of impervious cover. This development is private, which may make this retrofit difficult to implement, and public education is mostly limited to the Kulakane residents.

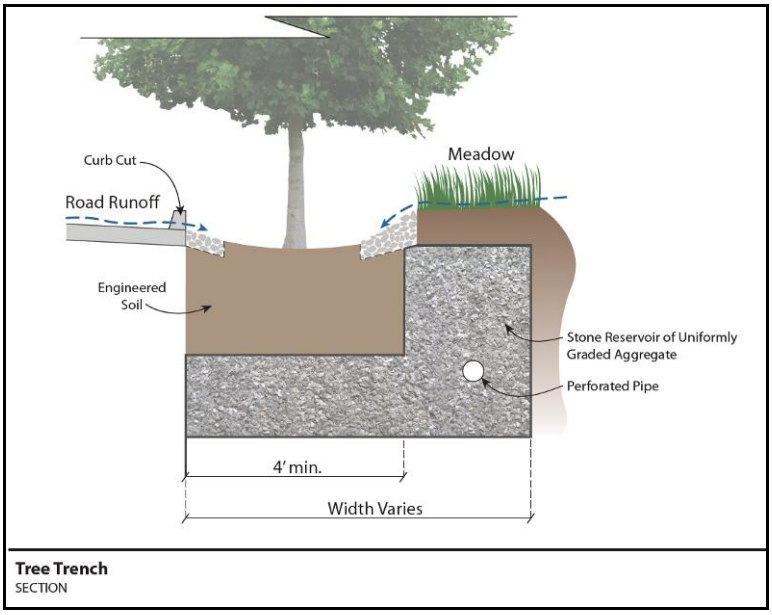
The drainage area and BMP footprint for this site is shown below (left); the existing low point in the parking lot is where overflows from the bioretention areas would be directed to the road drainage system (right).



2.4 Green Streets

Called “green streets,” “tree trenches,” or “tree filters” in other places, this type of design directs stormwater into shallow, planted swales with specific filtering media and a stone reservoir for holding more runoff volume. The large underground stone reservoir allows for a greater level of treatment when only a limited surface area is available.

Typical cross-section for “green streets” or “tree trenches” that are used along roadways to provide stormwater management.



R-2: HBP Parking Lot/Lower Honoapiilani Rd Green Streets

The stretch of Lower Honoapiilani Rd in front of HBP is heavily used, particularly for people going to the Park as well as the Farmer's Market and adjacent businesses on the mauka side. The road is superelevated here, sloped from mauka to makai, with a gutter line and catch basins along the edge of the HBP Parking Lot. Thus, the drainage area includes much of the HBP Parking Lot, all of the roadway, and the runoff from the Farmer's Market Plaza (1.8 acres, 67% impervious). Because parking is in such a demand here, it is important that this design maintain all of the parking spaces in the lot as well as along the road. There are utilities in this area to work around as well, such as utility poles, water, and sewer. However, the small island in between the road and parking lot, along with the areas striped for no parking, can be converted for stormwater management (1,600 sf pavement removal). Due to the overhead wires and to maintain views of the ocean, this design would not plant trees, instead using a variety of aesthetic and low maintenance grasses and shrubs. This project would occur mostly within the right-of-way (ROW), which is Maui County DPW ownership; although, Maui Parks and Recreation would also need to participate as a portion of the project would occur on the parking lot for HBP. This site has one of the highest public education potential of any in the watershed given its prominent location near a popular commercial area, a park, and within sight of the waters the project would help protect.

The island and no parking zones between the HBP Parking Lot and Lower Honoapiilani Rd provide an opportunity for green street stormwater management.

R-8: Haku Hale Place Green Streets

The proposed retrofits include (1) removing 600 sf of pavement in the center of the cul-de-sac and installing a bioretention area to treat runoff from the road and upgradient driveways and rooftops; and (2) removing 1,200 sf of parking lane to construct green street "bump-outs" at key locations. Overflow from these practices would be directed into the existing storm system. This project is located within the public ROW, but public education potential here is mainly for

just the cul-de-sac residents, and there may be concern/push back from the neighbors and the loss of some on-street parking.

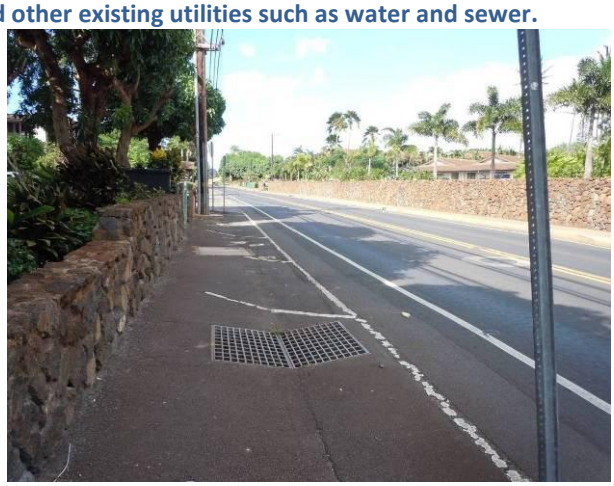
Looking down Haku Hale Place from the cul-de-sac turnaround with the bioretention footprint shown in green (left); and an example of a stormwater bump-out (right). Bump-out locations shown in the parking lane near Lower Honoapiilani Rd (bottom).

R-12: Lower Honoapiilani Rd Green Streets

Lower Honoapiilani Rd is a busy road used by vehicles, bikes, and pedestrians alike. In general, the road is crowned, with the high point along the centerline. There is a sidewalk on the mauka side of the street with many curb inlets for collecting stormwater. On the makai side, there is

limited parking (mostly striped for no parking), and a gutter line that directs stormwater into catch basins. The makai side presents an opportunity for better stormwater management. The paved shoulders that are striped for no parking (2,200 sf pavement removal) can be converted into stormwater swales with low maintenance grasses that slow, filter, and infiltrate runoff. The existing stormwater drainage system would be left in place for overflows from larger stormwater events to ensure the road does not flood. These swales would manage runoff from the makai half of the road and the portions of the adjacent properties that drain to the road (0.5 acres). This project is located fully within the public ROW (Maui County DPW property), and has high public education potential.

There are several no parking paved areas along Lower Honoapiilani Rd that could be converted for stormwater management. The design would need to work around other existing utilities such as water and sewer.

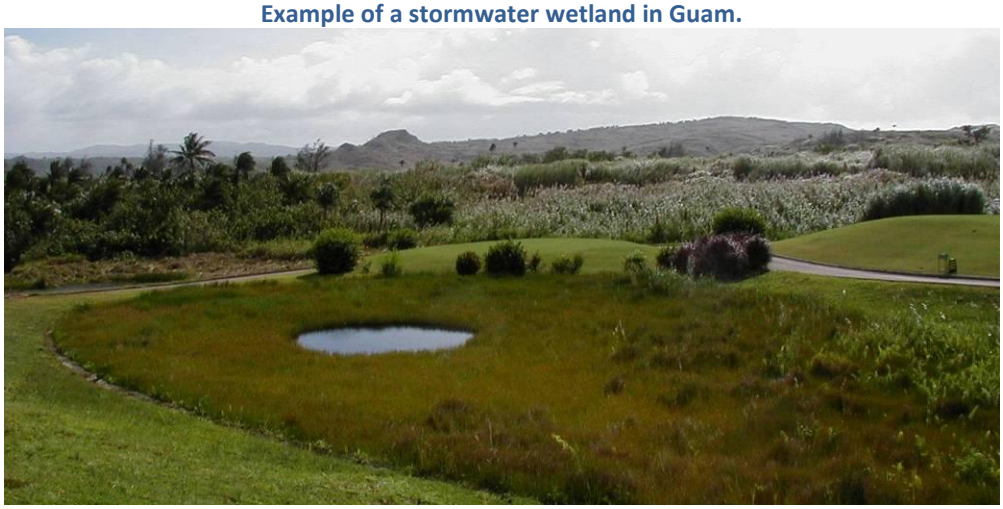


This graphic rendering illustrates how this road could be converted into "green streets" for stormwater management.

2.5 Constructed Wetlands

Constructed wetlands are stormwater practices that use high groundwater and wetland vegetation to treat and filter runoff. They typically require the most surface area for a given contributing drainage area of any of the BMPs. However, they can also be the most accessible to the public if designed with public access in mind (i.e., boardwalks).

Example of a stormwater wetland in Guam.



R-1: HBP – Constructed Wetland

This retrofit site at Honokowai Beach Park was the original goal of this project. All of the field work was performed to determine the actual drainage area to the HBP channel from the three main outfalls described in Chapter 1. A variety of stormwater BMPs were considered based on the drainage area results. For example, the original idea was to convert the HBP channel itself into a constructed wetland to treat runoff before it reached the ocean and the coral reefs. However, with a drainage area over 35 acres with 70% impervious cover, there was not enough space in the area around the channel to construct an effective wetland that could both treat the water from smaller events while allowing large flood waters to pass. With the park's bathhouse next to the channel, as well as DPW's maintenance access road, this BMP option was determined to be infeasible.

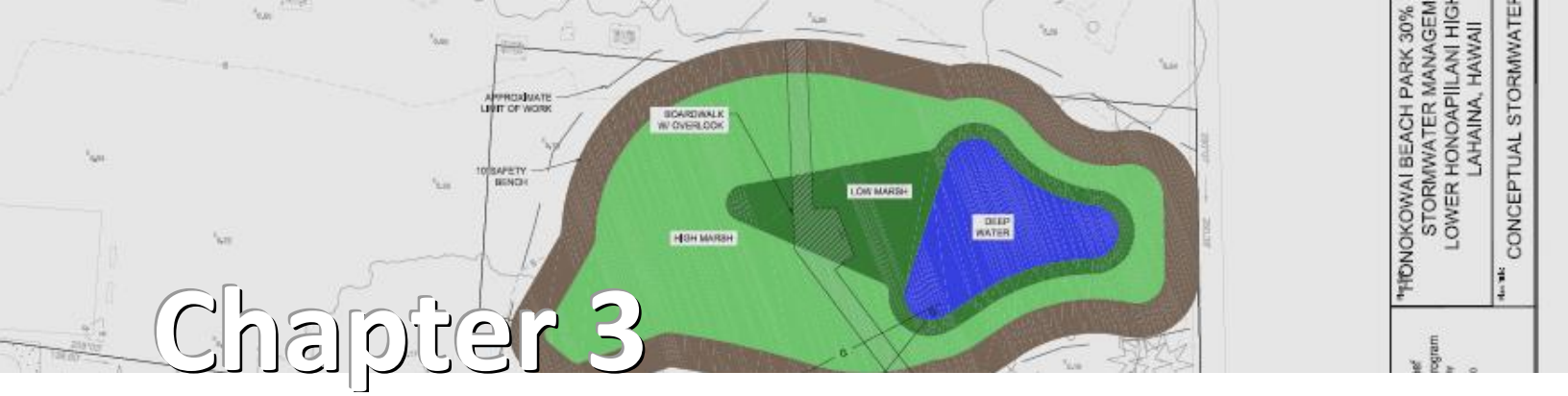
However, there was more space available along the northern end of the park for a constructed wetland. In this retrofit scenario, stormwater runoff from the small rain events would be diverted from the 7' x 1.5' box culvert (HBP-1) first into a pretreatment chamber to remove trash and sediment before flowing into a shallow constructed wetland. This wetland would treat runoff from 20 acres (62% impervious). At roughly 1.5% of the DA, the constructed wetland would need to be 13,000 sf at a minimum to treat the entire 1-inch water quality volume. Given the already limited space in this busy park, the constructed wetland was sized to treat only 0.5 inch with the goal of implementing additional retrofits at other sites in the same drainage areas. The constructed wetland was designed to avoid impacts to large shade trees in the park, to maintain pedestrian pathways with a boardwalk, and to provide educational signage. On-site discussions with Maui DPW and Parks and Recreation led to some minor tweaks in the design. However, follow-up discussions determined that the proposed retrofit would take up too much of the park's space. This project is still a part of this plan because it is by far the most effective retrofit opportunity in the watershed. There may come a time when integrated stormwater management becomes a more important piece in all of the public parks where there is accessible open space typically lacking on private lands.

View of the north end of HBP where the constructed wetland is proposed.

R-4: Vacant Land – Constructed Wetland

The residential property at 3614 Lower Honoapiilani Rd used to have a single-family house on it; however, the land is currently vacant. If this property could be purchased for stormwater purposes, it could provide vital space needed in this highly impervious watershed. It is in an ideal location, near the lowest point in the watershed, to provide stormwater management for surrounding properties. For purposes of this analysis, we assumed that only stormwater diverted from the Sunset Terrace drainage network would be directed into this property; however, it is possible that runoff from the storage unit/commercial lot could also be directed here. A constructed wetland is proposed here given the site's low elevation, and thus, assumed high groundwater, as well as the large drainage area (5.5 acres, 95% impervious). This site could also be designed as a park with boardwalks and sitting areas, to help relieve some of the pressure on HBP as well as provide additional educational opportunities.

Screenshot from Google StreetView, showing former residence (top); photograph of the same property during field work in September 2014 (bottom).



Chapter 3

Priority Concept Designs

The structural stormwater BMPs identified in Chapter 2 were ranked to determine the priority projects. The ranking process and the concept designs for the top three projects are included in this chapter.

3.1 Ranking Process

Twelve specific retrofits were identified as a part of this plan; however, implementing them all at one time is not feasible economically or logistically. Thus, it is helpful to have a method for determining which projects to focus on first when funds become available. The 12 identified structural stormwater opportunities were ranked based on the following factors to determine the highest priority sites:

- Treated runoff (40 points)
- Relative construction cost (25 points)
- Ease of Implementation:
  - Permitting (5 points)
  - Ownership issues (10 points)
  - Maintenance burden (5 points)
- Additional benefits/factors:
  - Public education/demonstration (10 points)
  - Available partners (5 points)

This process is described further in Appendix B. **Table 21** summarizes the site ranking (listed in descending order) with the detailed results included in the ranking spreadsheet (**Appendix B**).

Table 21. Structural Stormwater Retrofit Ranking

Site ID	Name	Score
R-3	**Lahuiokalani Church Rain Garden**	**74.8**
R-2	**HBP Lower Honoapiilani Rd Green Streets**	**66.2**
R-1	**HBP Constructed Wetland**	**61.2**
R-5	Former Parking Lot - Pavement Removal & Restoration	59.6
R-8	Haku Hale Place - Green Streets	58.8
R-12	Lower Honoapiilani Rd Green Streets	58.0
R-4	Vacant Land - Constructed Wetland	54.2
R-10	Hale Royale – Bioretention	53.3
R-6	Honokowai East Tennis Courts -Porous Surface	46.1
R-9	Leinani Apartments - Bioretention	43.0
R-7	The Breakers - retrofit existing detention basin	42.9
R-11	Kulakane - Bioretention	42.6

3.2 10% - 30% Designs

R-3: Lahuiokalani Church Rain Gardens

The top priority project based on the ranking process is Lahuiokalani Church rain gardens. This project ranked high due to its public education benefit and low cost. The rain gardens are sized to handle 1 inch of runoff from the church roof, for a total water quality volume of 160 cf. Assuming a rain garden depth of 6 inches, roughly 320 sf is required (approximately the same size as the nearby Wahikuli Rain Garden constructed in 2013). The required materials for this retrofit are minimal given that there are already downspouts and the surrounding lawn area is basically flat with no trees. Depending on the quality of the soils in this area, compost and sand amendments may be needed. Native plants that complement the church's existing landscaping are recommended. Perhaps the most important part of this project is to construct it as a part of a rain garden workshop to get the local community involved. The planning-level estimate for the rain garden project is $10,000 and includes the following material and labor:

- Archeologist
- Backhoe/operator
- 3 cy mulch (~3 inches deep)
- 3 cy compost (~3 inches deep)
- 3 cy sand (~3 inches deep)
- ~50 native, herbaceous plants
- 0.5 cy ¾ - 3 inch stone (at downspouts and as needed)
- Compost sock for ESC
- Grass seed for disturbed areas
- Hauling (for materials and waste removal)
- Workshop planning and advertising
- Tools/refreshments for volunteers
- Educational sign design and installation

Graphic rendering of proposed rain garden at the Lahuiokalani Church.

R-2: HBP Parking Lot/Lower Honoapiilani Rd Green Streets

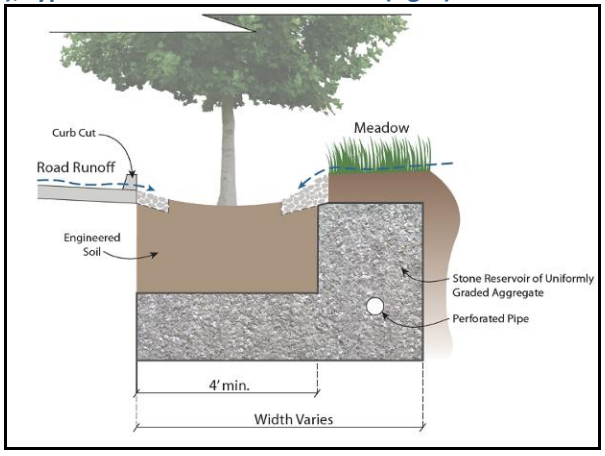
The green streets project adjacent to the HBP Parking Lot was the second highest priority project based on the ranking factors described above. This project ranked highly due to the high treatment volume (~3,500 cf), its location on public property, and high public education opportunity. Figure 6 shows a detailed map of the drainage area and the proposed footprint of the BMP.

The retrofit design utilizes the existing 4-ft "island" between the HBP Parking Lot and Lower Honoapiilani Rd. The edge of this island is the low point in the drainage area with catch basins capturing runoff from both the road and parking lot and conveying it into the 7'x1.5' box culvert (HBP-1). The concept is to remove this island, and the small no-parking areas along the road, and replace them with a long "tree trench" sized for the 1-inch rain event. Overflows from the trench would flow back into the existing storm drains via new overflow structures. The existing catch basins would be either removed or covered and left in place. The trench would be planted with low-growing, low-maintenance native plants to preserve the ocean view and protect the utilities (e.g., overhead wires, etc.).

The planning-level estimate for the Green Streets project is $200,000 and includes the following items that a contractor would be responsible for:

- New drainage structures for overflow (3)
- Cast-in-place concrete structures
- Paved flumes (inlets)
- 4" perforated PVC underdrain
- Stone aggregate
- Bioretention media (sand/compost mix)
- Filter fabric
- Mulch
- Native plants (grasses and shrubs)
- Modify existing crosswalk
- ESC Measures
- Educational sign design and installation

Existing island to be retrofitted into a tree trench (left); typical tree trench cross section (right).



Looking north at the existing island between HBP and Lower Honoapiilani Rd, with the existing catch basin identified with the yellow arrow (top). Graphic rendering of tree trench and flow paths (bottom).

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Legend

- R-2 Drainage Area
- Impervious Cover
- BMP Footprint
- Maui Parcels

Storm Drains

- Discharging to HBP-1
- Discharging to HBP-2
- Discharging to HBP-3
- Discharging to Mahinahina Stream
- 5-ft Contours

- Catch Basin
- Curb Inlet
- Outfall

N

0 50

1" = 50 Feet

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Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

Stormwater Retrofit R-2 Drainage Area Honokowai Water Quality Management Plan

Date: 2/12/2016

Figure 6

R-1: HBP – Constructed Wetland

The constructed wetland retrofit at HBP was the third highest priority project, due to the high amount of treatment provided (~22,000 cf), location on public land, and great public education opportunity. This retrofit has the most advanced design due to the project history. **Figure 7** shows a detailed map of the drainage area to the proposed constructed wetland, and **Figure 8** shows a 30% design plan for the site.

The retrofit design utilizes a diversion structure constructed in the 7'x1.5' concrete box culvert that would direct flows from small storm events (~0.5 inch) into the constructed wetland while allowing larger flows to continue in the culvert downstream to the HBP channel. Runoff would flow into a pretreatment tank first, which would capture debris and sediment. Then, runoff would flow into the deepwater zone of the constructed wetland and out into the surrounding low (6"-18" deep) and high marsh (0"-6" deep). The wetland was designed with a minimum 35% of the surface area as high marsh and at least 30% as low marsh, per standard shallow constructed wetland design criteria. A boardwalk with an overlook is proposed connecting existing pedestrian pathways out to the beach, as well as educational signage. The design attempted to protect and preserve the mature shade trees at the site, and grading could be adjusted even more if it were determined that the root systems are even more extensive than previously thought.

The planning-level estimate for the constructed wetland project is $500,000 and includes the following material items that a contractor would be responsible for:

- Diversion Structure
- 12" HDPE Pipe/Flared End
- Pretreatment Tank
- Topsoil and organic material
- Microtopography grading
- Native wetland plants
- Recycled plastic boardwalk
- ESC Measures
- Educational sign design and installation

Tree along the north end of the parking lot to be protected during construction.

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Legend

- R-1 Drainage Area
- Impervious Cover
- BMP Footprint
- Maui Parcels

Storm Drains

- Discharging to HBP-1
- Discharging to HBP-2
- Discharging to HBP-3
- Discharging to Mahinahina Stream
- 5-ft Contours

- Catch Basin
- Curb Inlet
- Outfall

N

0 200

1" = 200 Feet

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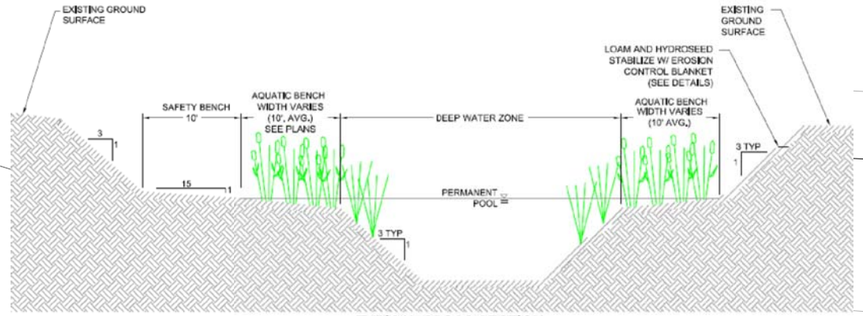
Stormwater Retrofit R-1 Drainage Area Honokowai Water Quality Management Plan

Date: 2/12/2016

Figure 7



TYPICAL CROSS SECTION

NOT TO SCALE

Revisions

Rev.	Date	By	Appr.	Description
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2				
3				
4				
5				
6				
7				

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508-833-3150 fax

Designed By: SLK | Drawn By: SLK | Checked By: MW/RAC

Date: OCTOBER 2014

Plan Title: CONCEPTUAL STORMWATER PLAN

Project: HONOKOWAI BEACH PARK 30% CONCEPT STORMWATER MANAGEMENT LOWER HONOAPIILANI HIGHWAY LAHAINA, HAWAII

Prepared For:
NOAA Coral Reef Conservation Program
1305 East West Highway
SSMC2, RM 11323
Silver Spring, MD 20910
Phone: ---
Fax: ---

Survey Provided By:
CDF Engineering, LLC.
PO Box 2985
Wailuku 96793
Phone: (808) 891-2400
Fax: (808) 897-2404
Dated: JUNE 2014

Registration:

DRAFT
NOT FOR CONSTRUCTION

Project Number: 13101

Sheet: 6 of **

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Chapter 4

Non-structural Stormwater Opportunities

Pollution prevention measures are considered "non-structural" vs. the structural stormwater practices discussed in Chapter 2. As you can see from Chapter 2, there is limited space and opportunity to implement structural practices to appropriately and effectively manage all of the runoff in the watershed. Luckily, implementing pollution prevention measures is one of the most proactive and cost-effective ways of improving watershed water quality. Pollution prevention requires: 1) identifying pollutants on a site with a high potential of coming into contact with stormwater; and 2) changing behaviors or implementing simple solutions to prevent that exposure. Examples include dumping wash water down the sink instead of into the gutter on the road, covering dumpsters and outdoor storage areas, storing buckets of oil or other fluids within a secondary containment unit, and moving maintenance operations away from streams and storm drain inlets.

A number of specific sites were identified during the field assessment where opportunities for pollution prevention measures were observed. In addition, there are several more general recommendations appropriate for this watershed, though no specific activity or problem was observed. These are all listed and described below, broken down into two main categories: (1) Source Control and (2) Education and Outreach.

4.1 Source Control

Source control refers to reducing the amount of pollutants that come into contact with stormwater. Sources relevant to the HBP watershed are listed below, though this may not be an exhaustive list.

- Wash water—Wash water should be properly disposed of rather than allowed to enter the storm drain system. Dirty mop buckets contain gray water and should be dumped into a sink connected to the sanitary sewer. Car wash areas should not discharge to the storm drain system without some form of advanced treatment or they should be connected to the sanitary sewer system.

This utility sink next to the laundry building at Hale Royale discharges on exposed soil and then down the steep driveway to a catch basin at the intersection with Lower Honoapiilani Hwy.

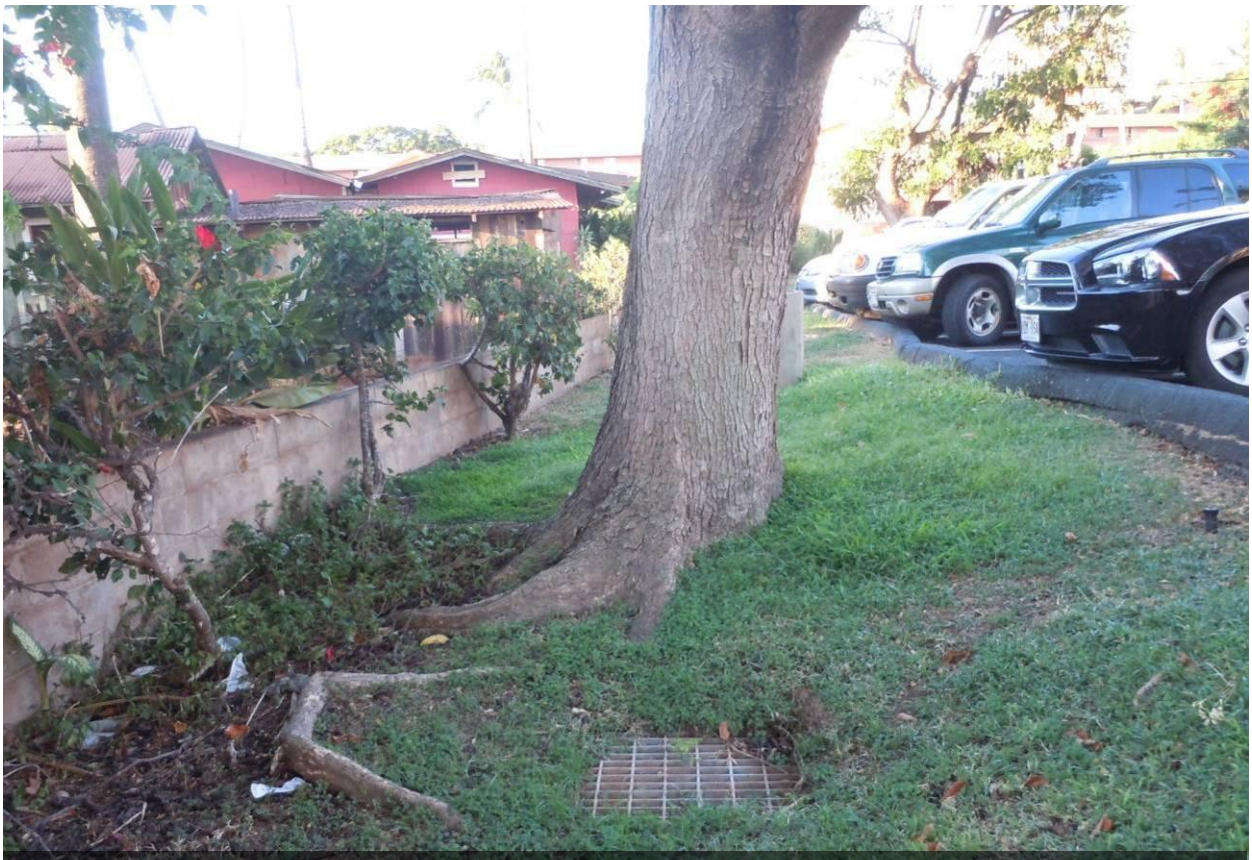
This is the identified (see sign) "Car Wash Station" at the Kulakane. Runoff from this area flows to the low point in the parking lot and out into Lower Honoapiilani Rd.

- Improved dumpster management—Covers reduce the amount of direct rainfall onto materials and secondary containment provides a barrier to leaking containers. Most dumpsters in the watershed did have covers, but almost all of them were located right next to catch basins. Moving dumpsters away from catch basins is a relatively inexpensive solution.

All of the dumpsters for this large complex (Hale Royale) are located right next to this catchbasin. The dumpsters do have lids, but there is still a risk of "dumpster juice" leaking directly into the storm drain.

Another dumpster located right next to a catch basin at Sunset Terrace (left). This dumpster at Maui Lani Terraces is actually placed directly on top of a catch basin (right).

- Proper landscape management—Homeowners and property managers should reduce the amount of fertilizers, spray irrigation, pesticides, or other chemicals applied to turf and landscaping. Landscaping debris should be kept out of the storm drain, and pet waste should be picked up in areas where dogs are frequently walked.



This catch basin is located in the landscaping area at Sunset Terrace near the back of the Farmer's Market Plaza. Flat grates like this one are easily clogged by vegetative debris, which can lead to flooding issues as well as adding more nutrients to the stormwater system.

Landscaping clippings and debris were directed into this catch basin at Maui Lani Terraces (left). This sign and baggy dispenser at Sunset Terrace is a great way to support the removal of pet waste and should be implemented at other developments in the watershed (right).

- Soil Stabilization — When bare soil is exposed to rainfall, the soil will erode and lead to sedimentation of downgradient stormwater structures and eventually streams and coral reefs. Bare areas should be stabilized as soon as possible with vegetation or rock to prevent sedimentation.

This downspout at Hale Royale discharges roof runoff onto exposed soil, which then is eroded and carried into the driveway and out into the street.

This property behind the Lahuiokalani Church (left) and a parking lot bump out at the Farmer's Market Plaza (right) both have areas of exposed soils that are contributing sediment in this watershed.

Sediment staining indicates soil erosion from these private residential roads between Maui Lani Terraces and Haku Hale Place (left) and north of Hale Royale (right).

The aerial from Google Earth shows the extensive areas of exposed soil in the single-family residential area to the north of Hale Royale.

- Vehicle Maintenance — Many of the residential developments had areas in the parking lots where vehicles (cars, boats, motorcycles, etc.) were being stored and/or maintained. Drippings from vehicles then flow into the storm drain. Residents should be encouraged to either take their vehicles to a shop for maintenance, or perform oil changes and other activities in an area far from a storm drain and properly clean up and dispose of supplies.

Oil stains are visible on the parking lot near a catch basin at Sunset Terrace (left); a motorcycle is being stored on top of a catch basin at Maui Lani Terraces (right).

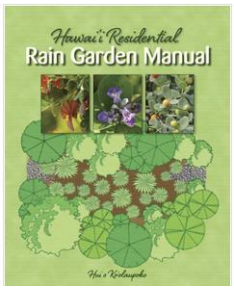
4.2 Education and Outreach Targets

Perhaps the most important and implementable recommendation is the continued effort to educate those that visit or live/work in the watershed, and those that use HBP. The case must be made to these stakeholders as to why they should engage in watershed stewardship activities, either through simple adjustments to everyday behaviors (e.g., I will start recycling) to more substantial commitments of time and resources (e.g., I will install this stormwater retrofit to manage runoff from my parking lot). Raising awareness of the issues is not enough. The goal of a good education program is to inspire long-term engagement and activism. While overarching messages relating land use activities directly to coral reef health are needed throughout the area, audience-specific messages should also be targeted to businesses, government employees, and in some cases, tourists. Audience-specific messages are discussed below in more detail.

Condominium Property Managers: Distribute educational materials to property managers to make sure they are aware of the issues facing coral reefs. The *Hawai'i Hotel Reef Stewardship Guide* (Coral Reef Alliance, 2014) is a great resource to hand-out. Once aware of the issues, residents and property managers should have the most knowledge of their on-site materials and procedures that may inadvertently lead to contaminated runoff. They are ultimately responsible for the implementation of voluntary and regulated pollution prevention measures on their properties.

This grassy area next to a downspout provides and excellent opportunity for a rain garden at Sunset Terrace.

Commercial properties: There are only a few commercial properties in the watershed, but they could have an impact by helping to educate their patrons. In particular, the Farmer's Market is a great place for distributing flyers for clean-up events or information on rain gardens.



Single-family house owners: While certainly a smaller percentage in this watershed, owners of single-family houses can also play a role in improving water quality. Rain gardens are relatively easy, low-cost, aesthetic ways that homeowners can help out. The *Hawai'i State Rain Garden Manual* (HOK, 2013) could be distributed electronically (advertise the website) or as a hardcopy.

Catch basins along Lower Honoapiilani should be stenciled to let people know that they discharge into the ocean.

Maui County DPW: The drainage system on Lower Honoapiilani Rd is the major stormwater infrastructure in this watershed. DPW is responsible for maintenance of this system as well as the HBP Channel itself. DPW workers should be educated on stormwater issues as they relate to coral reefs. In addition, DPW could consider installing storm drain markers and/or hosting a volunteer work day to do storm drain stenciling for both DPW-owned catch basins and curb inlets as well as private structures that connect to the DPW system.

Maui County Parks and Recreation: Parks and Recreation operate and maintain HBP. This park would be a great place to serve as Watershed Outreach Central to get the message out to residents and tourists alike. A kiosk and/or signage could be placed at the park with information on stormwater impacts and how people can do their part to protect coral reefs.

Chapter 5

Next Steps

There are many potential restoration activities presented in this management plan, both structural and non-structural. The ranking process provides a road map for how to approach implementation, but opportunities may arise that push one retrofit to the top of the list before others. Regardless of which retrofit, the next steps in implementation have both permitting considerations and coordination with project partners.

5.1 Permitting Considerations

Permitting requirements will vary depending on the location and size of each project. However, the following is a preliminary list of permits to consider when moving forward with retrofit implementation:

- Special Management Area Use Permit – County of Maui Office of Planning, for work within the SMA (the entire watershed is within the SMA). A Shoreline Setback Certificate may be needed depending on proximity to ocean.
- Flood Development Permit – County of Maui Office of Planning
- Environmental Assessment - See the "Guide to the Implementation and Practice of the Hawaii Environmental Policy Act" published in 2012 by the Office of Environmental Quality Control (OEQC) to determine if one is needed. http://dlnr.hawaii.gov/occl/files/2013/07/Guide-to-the-Implementation-and-Practice-of-the-HEPA.pdf
- State Historic Preservation - See here: http://dlnr.hawaii.gov/shpd/ Excavation close to the ocean will most likely trigger archeological monitoring/studies.
- Stormwater Permit (County of Maui DPW)
- Grading Permit (County of Maui DPW)
- NPDES Construction Stormwater Permits are needed for projects that disturb 1 acre or more.
- Section 401 WQC Application
- Consult with Maui County Arborist

5.2 Project Partners

Project partners can make all the difference in whether a management plan is successfully implemented or not. NOAA CRCP, along with West Maui Ridge 2 Reef Initiative, are the

sponsors for this management plan. Other key project partners for the HBP Watershed are the property owners of the priority retrofit sites:

- Maui County DPW (property owners for the public roads and responsible for maintenance for a portion of HBP)
- Maui County Parks and Recreation (managers for the majority of HBP)
- State of Hawaii (property owners of large, abandoned parking lot parcel along Honoapiilani Highway)
- Hawaii Conference of the United Church of Christ (property owners at historical church)

Property owners should be brought into the planning process as soon as possible, and hopefully, will become the projects' biggest proponents throughout design and construction. They may also be willing and able to provide funding for the retrofits. Other sources of funding for urban stormwater retrofitting include EPA's 319 program and capital improvement grants, CZM funds, NFWF, FEMA, USFWS, and NOAA, particularly where impaired waters, sensitive habitats, or flooding issues are involved. Where retrofits can be associated with road runoff, the Department of Transportation may offer funding.

APPENDIX A:

EXISTING CONDITIONS PLAN

FOR HBP

HONOKOWAI BEACH PARK

Being a portion of the Government (Crown) Land of Honokowai
(portion of Lot 4, Honokowai Government Remnants)
and R.P. 4205 L.C. Aw.4254Apana 2 to Kaumauma
Situated at
Honokowai, Lahaina (Kaanapali), Maui, Hawaii

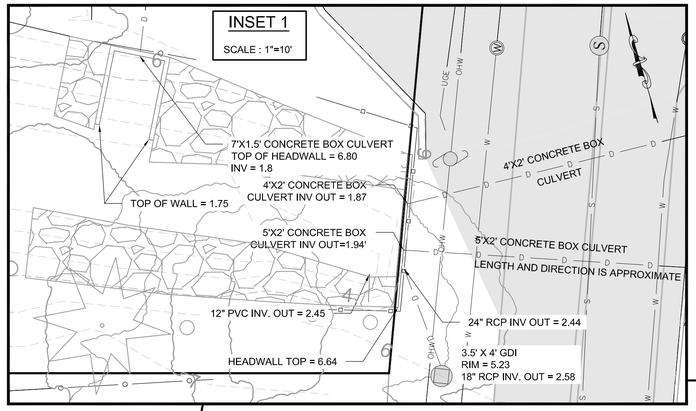
SURVEY NOTES

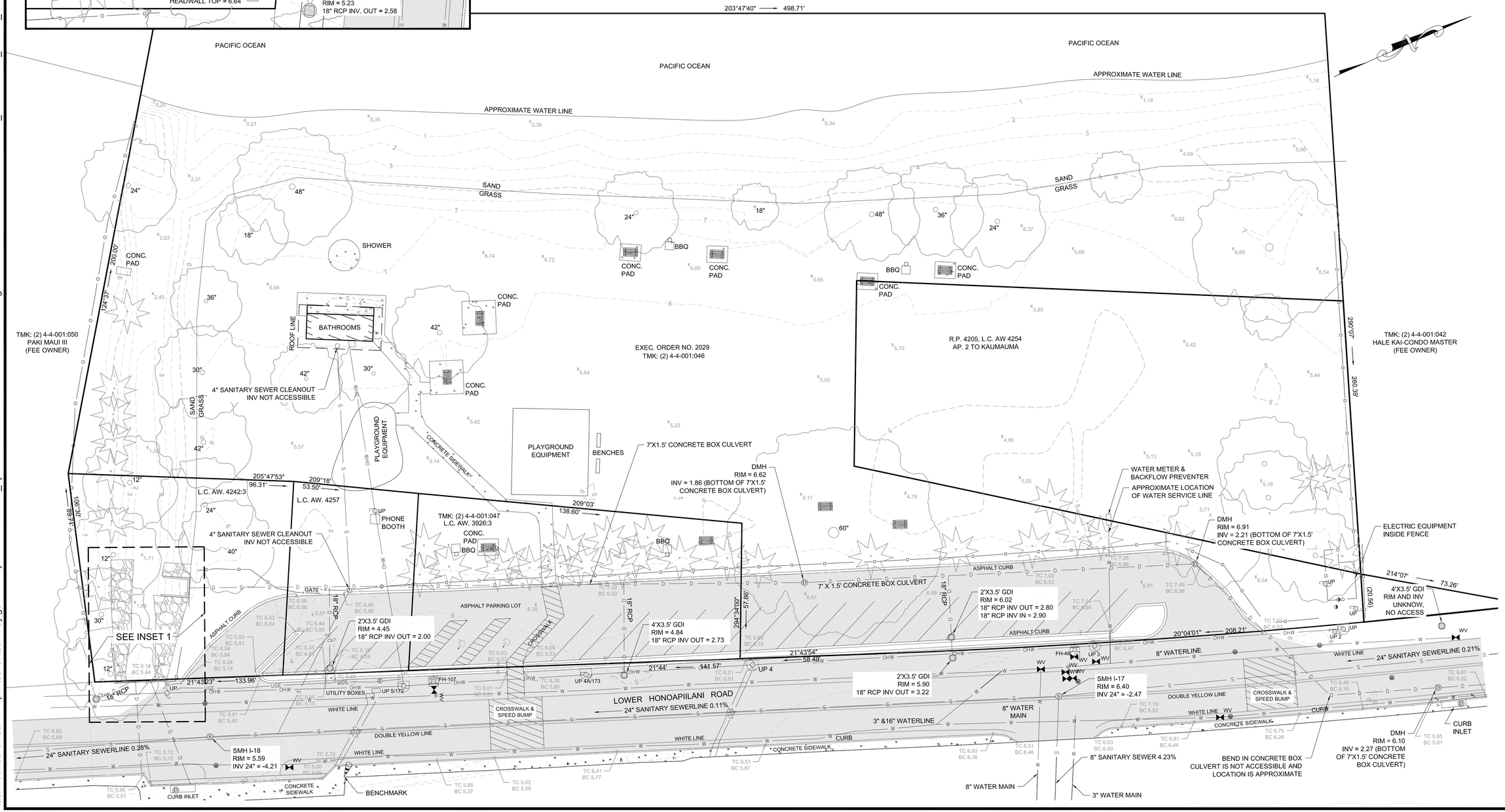
1. THE TOPOGRAPHY AND EXISTING SITE CONDITIONS DEPICTED HEREON ARE THE RESULT OF AN ON THE GROUND FIELD SURVEY CONDUCTED BY CDF ENGINEERING, LLC. JUNE 5, 2014.
2. HORIZONTAL DATUM IS REFERENCED TO GOVERNMENT TRIANGULATION STATION "PUU KOLII" (MANINI).
3. THE ELEVATIONS DEPICTED HEREON WERE BASED ON LMSL AND REFER TO USGS BM TU3104.
4. BENCH MARK IS A + IN CONCRETE ALONG LOWER HONOAPIILANI ROAD WITH COORDINATES OF N:9104.93 E:-12619.62 ELEV:5.7
5. THE PROPERTY LINES AND RIGHTS OF WAYS DEPICTED HAVE BEEN ESTABLISHED BY FIELD SURVEY AND DEEDS AND PLANS OF RECORD OR ARE THE RESULT OF A CLASS 1 SURVEY OR ARE APPROXIMATE ONLY.
6. THE ACCURACY OF MEASURED PIPE INVERTS,PIPE SIZES, AND UNDERGROUND UTILITY LOCATIONS IS SUBJECT TO FIELD CONDITIONS, THE ABILITY TO MAKE VISUAL OBSERVATIONS, DIRECT ACCESS TO THE VARIOUS ELEMENTS AND OTHER CONDITIONS.
7. THE PROPERTY IS LOCATED WITHIN FEMA FLOOD HAZARD ZONES AE & VE. FIRM INDEX DATE: SEPTEMBER 19, 2012
8. THE LOCATION AND/OR ELEVATION OF EXISTING UTILITIES AND STRUCTURES AS SHOWN ON THESE PLANS ARE BASED ON RECORDS OF VARIOUS UTILITY COMPANIES, AND WHEREVER POSSIBLE, MEASUREMENTS TAKEN IN THE FIELD. THIS INFORMATION IS NOT TO BE RELIED UPON AS BEING EXACT OR COMPLETE. THE LOCATION OF ALL UNDERGROUND UTILITIES AND STRUCTURES SHALL BE VERIFIED IN THE FIELD PRIOR TO THE START OF ANY CONSTRUCTION. THE CONTRACTOR MUST CONTACT THE APPROPRIATE UTILITY COMPANY, ANY GOVERNING PERMITTING AUTHORITY IN THE CITY OF LAHAINA AND/OR THE COUNTY OF MAUI, AND "HAWAII ONE CALL CENTER" (1-866-432-7287) AT LEAST 72 HOURS PRIOR TO ANY EXCAVATION WORK IN PREVIOUSLY UNALTERED AREAS TO REQUEST EXACT FIELD LOCATION OF UTILITIES.
9. ALL TREE DIAMETERS ARE APPROXIMATE. COCONUT TREES ARE ALL APPROXIMATELY 6" IN DIAMETER.
10. UTILITY LOCATION AND INFORMATION WAS TAKEN FROM THE PLANS ENTITLED "NAPILI-HONOKOWAI SEWERAGE SYSTEM SEWER LINE I STA. 17+00 TO 182+50" AND "NAPILI-HONOKOWAI SEWERAGE SYSTEM SEWER LINES I, IB, & J STA. 182+50 TO 193+50" BY THE COUNTY OF MAUI DEPARTMENT OF PUBLIC WORKS DATED FEBRUARY 2, 1983.

GRAPHIC SCALE

20 0 10 20 40 80

(in feet)
1 INCH = 20 FEET





Revisions

Rev.	Date	By	Appr.	Description
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508-833-3150 fax

Checked By: ---
Drawn By: ---
Designed By: ---
Date: JULY 2014

Plan Set: HONOKOWAI BEACH PARK
STORMWATER MANAGEMENT
LOWER HONOAPIILANI HIGHWAY
LAHAINA, HAWAII

Plan Title: EXISTING CONDITIONS PLAN

Prepared For:
NOAA Coral Reef
Conservation Program
1325 East West Highway
SSMC2, RM 11323
Silver Spring, MD 20910

Survey Provided By:
CDF Engineering, LLC.
PO Box 2985
Wailuku, 96793
Phone: (808) 891-2400
Fax: (808) 897-2404
Dated: JUNE 2014

Registration:
This map was prepared by me or under my direct supervision.

Leslie K.T. Lau
Registered Professional Land Surveyor
State of Hawaii Certificate Number LS12978
License Expiration Date: 30 April 2016

Project Number: 13101
Sheet : 3 of
Sheet Number: C - 3

last modified: 07/29/14 printed: 07/29/14 by gc H:\Projects\NOAA\CRCP_5yrBA\13101 TO#4.1 Wahikuli Retrofit\Drawings - 13101\13101-XREF-OTHERS\140618_HONOKOWAI_BEACH_PARK.dwg

APPENDIX B:

RETROFIT RANKING METHODOLOGY AND RESULTS

APPENDIX B – Retrofit Ranking Methodology

The recommended stormwater retrofits sites identified within this plan will likely not be implemented simultaneously; therefore, each of the evaluated retrofit sites were subject to a ranking procedure in order to help prioritize locations for further evaluation. Not all recommendations are equal when it comes to implementation. Some proposed projects may require additional planning and permitting, both of which will require additional time, while others may require a large amount of upfront construction costs. Prioritizing candidate sites allows retrofit sites to be compared to find the most cost-effective and feasible sites within the study area. The ranking system used a 100-point scoring system, where the relative merit of each proposed retrofit BMP was evaluated by assigning points based on the following site BMP ranking criteria:

- Pollutant Removal Potential (40 points)
- Relative Construction Cost (25 points)
- Ease of Implementation (20 points) including:
    - Wetland impact/permitting
    - Ownership
    - Maintenance burden
- Additional Benefits (15 points) including:
    - Public education/demonstrations
    - Available partners

1) **Pollutant Removal Potential (40 points)--**This category was allotted the highest number of possible points based on the main goal of addressing water quality in the stormwater discharges to the coral reef near HBP. We analyzed this category based on water quality volume treated (with a goal of 1 inch per impervious acre per Maui County standards), as well as the most currently accepted removal efficiencies for the proposed practices as documented in the 2010 Rhode Island Stormwater Design Manual (see Table 1). Note, the 2010 RI Manual was used because it reflects some of the latest research results on pollutant removal capabilities.
    - Water Quality Volume Treated - The site with the maximum volume treated received 20 points, while the minimum received 10 points, and the remaining sites were ranked accordingly.

    - Pollutant Reduction – The practices were ranked based on their removal efficiency for sediment (TSS), bacteria, phosphorus, and nitrogen, for a maximum of 20 points possible (5 points each pollutant).

Table 1. Pollutant Removal Efficiencies (Source: 2010 Rhode Island Stormwater Design Manual)

Practice	%TSS Removal	% Bacteria Removal	%TP Removal	%TN Removal
Constructed Wetland	85	60	48	30
Bioretention	90	70	30	55
Permeable Paving	90	95	40	40
Rain Garden	90	70	30	55
Green Streets	90	70	30	55
Basin Retrofit	25	12	8	3

2) **Relative Construction Cost per Treatment Volume (25 points)—** Relative scores were assigned to each project (high, medium, low) where the lowest relative cost was assigned 25 points and the highest cost was assigned 5 points.

3) **Ease of Implementation (20 points)--**This category compared the concepts based on the following implementation factors:

- Permitting
    - Minimal to no permitting required = 5 points;
    - Some permitting likely = 2.5 points; and
    - Complicated permitting likely = 0 points.

- Ownership issues
    - Publically-owned = 10 points;
    - Ownership potentially an issue = 5 points; and
    - Privately-owned = 0 points.

- Maintenance burden
    - Low = 5 points;
    - Medium = 2.5 points; and
    - High = 0 points.

4) **Additional benefits/factors (15 points).** This category helps compare the proposed concepts based on additional factors of interest to this project, as listed below:

- Public Education/Demonstration
    - Site is located in a high visibility area and provides an excellent opportunity for reaching the public = 10 points:
    - Site provides moderate visibility and located where some portion of the public could benefit = 5 points; and
    - Site provides low visibility and is located in an area few people will visit = 0 points.

- Available partners
    - Good opportunity for, or there are existing partners/funding/volunteers available for implementation = 5 points:
    - Some opportunity for implementation assistance = 2.5 points
    - Little to no opportunity for implementation assistance = 0 points

APPENDIX B - Honokowai Retrofit Ranking Spreadsheet

Note: Water Quality Volume Required is based upon 1 inch of runoff times the Runoff Coefficient per Maui Stormwater Design Rules

Preliminary Sizing Calculations for Stormwater Retrofits:

#	Project	% Imp.	Drainage Area		Imp. Area		WQv Required	WQv provided	WQv provided	TSS removed	Bacteria removed	TP removed	TN removed	Pavement Removed (sf)	Relative Cost $	Permitting	Ownership Issues	Maintenance Burden	Public ed	Other Partners
		%	ac	sf	ac	sf	cf	%	cf	%	%	%	%							
R-1	HBP - Constructed wetland	61.9	20.36	886,882	12.60	548,856	44,860	50.0	22430	85	60	48	30	-	H	H	M	L	H	H
R-2	HBP/Lower Honoapiilani Rd - Green Streets	66.7	1.80	78,408	1.20	52,272	4,247	81.5	3461	90	70	30	55	1,600	M	M	L	H	H	H
R-3	Church-Rain garden	100.0	0.05	2,004	0.05	2,004	159	100.0	159	90	70	30	55	-	L	L	M	L	H	M
R-4	Vacant Land -Constructed wetland	94.5	5.50	239,580	5.20	226,512	17,987	100.0	17987	85	60	48	30	-	H	M	H	L	H	M
R-5	State Parking Lot - pavement removal & restoration	100.0	0.89	38,600	0.89	38,600	3,056	100.0	3056	90	95	40	40	38,600	L	M	H	L	L	M
R-6	Honokowai East-Porous surface (tennis courts)	100.0	0.28	12,135	0.28	12,135	966	100.0	966	90	95	40	40	12,135	M	L	H	M	L	L
R-7	The Breakers - basin retrofit/cisterns	100.0	2.00	87,120	2.00	87,120	6,897	100.0	6897	25	12	8	3	-	M	M	H	L	M	L
R-8	Haku Hale Place - Green Streets	67.4	1.50	65,340	1.01	44,047	3,576	100.0	3576	90	70	30	55	1,800	M	M	L	H	M	M
R-9	Leinani Apartments-Bioretention	100.0	0.50	21,780	0.50	21,780	1,724	100.0	1724	90	70	30	55	-	M	M	H	M	L	L
R-10	Hale Royale-Bioretention	100.0	0.70	30,492	0.70	30,492	2,414	100.0	2414	90	70	30	55	-	L	M	H	M	L	L
R-11	Kulakane-Bioretention	100.0	0.30	13,068	0.30	13,068	1,035	100.0	1035	90	70	30	55	1,000	M	M	H	M	L	L
R-12	Lower Honoapiilani Rd - Green Streets	100.0	0.50	21,780	0.50	21,780	1,724	100.0	1724	90	70	30	55	2,200	H	M	L	M	H	H

Ranking Results:

Site #	Project	1. Pollutant Removal Potential (possible 40 pts)			2. Cost (25 p	3. Ease of Implementation (20 points)				4. Additional Benefits/Factors (15 points)			TOTAL SCORE
		Total WQv treated **(20)**	Pollutant Reduction **(20)**	**#1 Score**	Relative Cost	Permitting **(5)**	Ownership **(10)**	Maintenance Burden **(5)**	**#3 Score**	Public Education/ Demonstration **(10)**	Other Partner Involvement **(5)**	**#4 Score**	
R-1	HBP - Constructed wetland	20.00	11.2	**31.2**	**5.0**	0	5	5	**10**	10	5	**15**	**61.2**
R-2	HBP/Lower Honoapiilani Rd - Green Streets	11.48	12.3	**23.7**	**15.0**	2.5	10	0	**12.5**	10	5	**15**	**66.2**
R-3	Church-Rain garden	10.00	12.3	**22.3**	**25.0**	5	5	5	**15**	10	2.5	**12.5**	**74.8**
R-4	Vacant Land -Constructed wetland	18.00	11.2	**29.2**	**5.0**	2.5	0	5	**7.5**	10	2.5	**12.5**	**54.2**
R-5	State Parking Lot - pavement removal & restoration	11.30	13.3	**24.6**	**25.0**	2.5	0	5	**7.5**	0	2.5	**2.5**	**59.6**
R-6	Honokowai East-Porous surface (tennis courts)	10.36	13.3	**23.6**	**15.0**	5	0	2.5	**7.5**	0	0	**0**	**46.1**
R-7	The Breakers - basin retrofit/cisterns	13.03	2.4	**15.4**	**15.0**	2.5	0	5	**7.5**	5	0	**5**	**42.9**
R-8	Haku Hale Place - Green Streets	11.53	12.3	**23.8**	**15.0**	2.5	10	0	**12.5**	5	2.5	**7.5**	**58.8**
R-9	Leinani Apartments-Bioretention	10.70	12.3	**23.0**	**15.0**	2.5	0	2.5	**5**	0	0	**0**	**43.0**
R-10	Hale Royale-Bioretention	11.01	12.3	**23.3**	**25.0**	2.5	0	2.5	**5**	0	0	**0**	**53.3**
R-11	Kulakane-Bioretention	10.39	12.3	**22.6**	**15.0**	2.5	0	2.5	**5**	0	0	**0**	**42.6**
R-12	Lower Honoapiilani Rd - Green Streets	10.70	12.3	**23.0**	**5.0**	2.5	10	2.5	**15**	10	5	**15**	**58.0**

Site Priority In Descending Order

Site #	Score
R-3	74.8
R-2	66.2
R-1	61.2
R-5	59.6
R-8	58.8
R-12	58.0
R-4	54.2
R-10	53.3
R-6	46.1
R-9	43.0
R-7	42.9
R-11	42.6